EMMETT

A Study of the Phosphorus Content Of Flesh

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ARTHUR DONALDSON EMMETT, B. S., 1901

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Mr Arthur Donaldson Emmett.

ENTITLED A Study of the Phosphorus Content of Flesh.

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Master of Arts.

H. S. Grindley.

HEAD OF DEPARTMENT OF General Chemistry

A STUDY OF THE PHOSPHORUS CONTENT OF FLESH.

INTRODUCTION.

The most important of the foods in the dietary of man, from a nutritive standpoint, is undoubtedly meat. In this are contained about all of the essential ingredients for the development, nourishment and maintainence of the vital organs, nerves, tissues, etc. In short, meat is to humanity what fuel is to industry - the neucleus from which all else springs.

In this laboratory, during the past eight years, special stress has been put upon the study of meats with the object of contributing both scientific and practical information to the meager knowledge upon the subject.

This investigation has been carried along the following lines: Studies (1) upon the losses resulting from the cooking of meats by different methods - frying, sautéing, pan-broiling, pot-roasting, oven-roasting, and boiling;[1] (2) on the ease of both the natural and artificial digestion of cooked meats;[2] (3) on the influence of the different methods of cooking upon the nutritive value of meats;[3] (4) on the nitrogenous constituents of meat;[4] (5) on the chemical composition of both raw and cooked meats, bearing in mind not only the method of cooking, but the age, feed and breed of the animal;[5] and (6) on the improvements of the methods of

analyzing meats.[6]

From the very beginning of these studies, the ordinary methods of analysis were found to be poorly adapted to such complexed organic substances as meats, broths and drippings, which are peculiarly subject to changes due to temperature, manipulation and etc. Many modifications had to be resorted to, before anything like uniform results could be obtained, and even then a harder problem resulted - the interpretation of the results. For it was found that the method, as first adopted, while it gave fairly accurate results, so altered the original composition of the meat that the data represented something other than that sought. For example, instead of analyzing the fresh sample, as is now done the meat was first air-dried at 50-60^{0}C., for several days. In this way, many of the soluble organic constituents were rendered insoluble, much of the albumen was coagulated, some of the proteids were probably changed to albumoses and in turn some of the albumoses to peptones, some of the fat was oxidized, and finally some ammonia was driven off. Another great advantage to be gained from this modification was the saving of time and the delay in obtaining results.

Again, the ordinary method was found to be too incomplete. Nothing could be ascertained as to the nature of the different forms of nitrogen, of the organic extractives and of the ash. Hence it was, that the next important modification in the method, was that of introducing the so called cold water extraction of the meat. In this manner a very large percentage of the components, which enter into the role of producing the flavor in meats, which have much influence in exciting the various glands associated with

the digestive organs, and which one would naturally expect to vary most- except that of fat - in different animals and breeds of animals, are separated from the meat. As a result of this valuable step, together with that of analyzing the fresh substance directly, it is possible to obtain a far better insight into the value of the meat, be it raw or cooked.

Table I, represents the method as originally used. Table II, represents the method as modified for analyzing the fresh substance directly, Table III, represents the method as now in use.

Table 1
Chemical Composition of Airdried Meat Calculated to Fresh Substance

Laboratory No.	Kind of Meat	Water %	Proteid (Nitrogen X 6.25) %	Fat %	Ash %	Total %	Total Nitrogen %
1643	Beef, round, boiled	60.57	33.89	5.49	.64	100.59	5.42
1647	Beef, round, raw	73.76	20.73	4.52	1.07	100.08	3.32
1650	Beef, sirloin, raw	74.96	21.06	3.06	1.10	100.18	3.37
1656	Veal, leg, raw	75.92	21.75	.88	1.12	99.67	3.48
1665	Beef, neck, boiled	55.44	31.28	13.13	.47	100.32	5.00
1652	Veal, leg, boiled	63.79	33.37	1.53	.97	99.66	5.34
1674	Beef, rump, pan-boiled	27.44	23.54	47.50	1.15	99.63	3.77
1676	Beef, rump, raw	52.38	14.66	32.47	.71	100.22	2.34
1692	Beef, round, raw	76.40	20.41	2.27	1.04	100.12	3.27
1704	Beef, rump, boiled	55.05	28.55	15.94	.70	100.24	4.57
	Average	61.57	24.93	12.70	.90	100.07	3.99

Table 2
Chemical Composition of Fresh Meat Calculated in Per cent of the Fresh Substance

Laboratory No.	Kind of Meat	Water %	Proteid (Nitrogen X 6.25) %	Fat %	Ash %	Total %	Total Nitrogen %
1643	Beef, round, boiled	60.52	33.58	5.66	.74	100.50	5.37
1647	Beef, round, raw	74.18	20.96	4.28	1.28	100.70	3.35
1650	Beef, sirloin, raw	75.46	21.27	3.08	1.02	100.95	3.40
1656	Veal, leg, raw	75.97	21.47	.96	1.15	99.55	3.47
1665	Beef, neck, boiled	54.40	31.49	13.68	.47	100.04	5.04
1652	Veal, leg, boiled	64.73	33.53	1.59	1.01	100.86	5.31
1674	Beef, rump, panbroiled	27.46	23.66	47.39	1.18	99.69	3.79
1676	Beef, rump, raw	52.26	15.00	32.38	.74	100.38	2.40
1692	Beef, round, raw	76.22	20.93	2.36	1.08	100.59	3.35
1704	Beef, rump, boiled	55.01	28.64	16.07	.68	100.40	4.58
	Average	61.62	25.05	12.75	.94	100.37	4.01

Table 3
Chemical Composition of Meat by the Improved Methods of Analysis
Fresh Substance

Laboratory No	Kind of Meat	Water %	Dry Matter: Soluble %	Dry Matter: Insoluble %	Dry Matter: Total %	Proteid: Soluble: Coagulable %	Proteid: Soluble: Albumose %	Proteid: Soluble: Peptone %	Proteid: Soluble: Total %	Proteid: Insoluble %	Proteid: Total %
1850	Beef, round, raw	74.89	7.26	18.00	25.26	2.62	.23	.08	2.93	15.67	18.60
1823	Beef, round, raw	75.61	6.21	18.19	24.40	2.08	.23	.10	2.41	15.97	18.38
1857	Veal, breast, raw	63.34	4.65	31.86	36.51	1.55	.18	.06	1.79	15.10	16.89
1860	Veal, leg, raw	73.40	5.81	21.50	27.31	1.52	.22	.10	1.84	16.28	18.12
1831	Beef, ribs, roast	44.78	2.76	52.32	55.08	.36	.14	.02	.52	15.30	15.82
1838	Beef, ribs, roast	49.73	3.04	47.63	50.67	.26	.12	.00	.38	19.65	20.03
1829	Beef, round, pot-roast	57.57	3.24	39.61	42.85	.00	.43	.03	.46	35.14	35.60
1825	Beef, round, pot-roast	56.92	4.24	40.11	44.35	.00	.32	.05	.37	34.32	34.69
1824	Beef, round, boiled	55.96	2.92	41.69	44.61	.00	.39	.02	.41	33.01	33.42
1808	Beef, round, boiled	61.70	1.76	37.24	39.00	.00	.19	.14	.33	33.45	33.78

Table 3 (continued)

Organic Extractives: Nitrogenous %	Organic Extractives: Non-nitrogenous %	Organic Extractives: Total %	Fat %	Ash: Soluble %	Ash: Insoluble %	Ash: Total %	Nitrogen: Soluble: Proteid %	Nitrogen: Soluble: Non-proteid %	Nitrogen: Soluble: Total %	Nitrogen: Insoluble %	Nitrogen: Total %	Ratio of non-proteid to proteid: In water extract (Ratio)	Ratio of non-proteid to proteid: In meat (Ratio)
1.34	2.00	3.34	2.24	.99	.09	1.08	.469	.431	.900	2.506	3.406	1:1.09	1:7.91
1.26	1.54	2.80	2.14	1.00	.08	1.08	.386	.402	.788	2.556	3.344	1: .96	1:8.32
.78	1.42	2.20	16.52	.66	.24	.90	.286	.251	.537	2.416	2.953	1:1.14	1:11.76
1.21	1.87	3.08	5.02	.89	.20	1.09	.292	.387	.679	2.605	3.284	1: .75	1: 8.49
.77	.82	1.59	36.84	.65	.18	.83	.082	.248	.330	2.449	2.779	1: .33	1:11.21
.91	1.04	1.95	27.79	.71	.19	.90	.060	.292	.352	3.144	3.496	1: .21	1:11.97
1.01	1.09	2.10	4.20	.68	.27	.95	.073	.322	.395	5.623	6.018	1: .23	1:18.70
1.31	1.53	2.84	5.58	1.03	.21	1.24	.059	.419	.478	5.491	5.969	1: .14	1:14.24
.83	1.06	1.89	8.47	.62	.21	.83	.039	.266	.305	5.306	5.611	1: .15	1:21.10
.47	.54	1.01	3.65	.42	.14	.56	.053	.151	.204	5.351	5.555	1: .35	1:36.79

From the data above, the differences in the various steps can easily be seen. However, had a cold water extract been made of the samples after airdrying, the differences in table I and III would have been much more marked, especially as regards the forms of nitrogen. Yet, by referring to the last table, it is quite evident that a great advance had been taken in separating the different constituents in flesh, and with the hope of furthering this movement, the present work was undertaken at the suggestion of Dr. H. S. Grindley.

Phosphorus occurs in nature, not in the free state but as phosphates and by disintegration of minerals associated with it, it passes into the soil and thence by absorption into plants which in turn are consumed by animals. Thus it is that both vegetable and animal life contain phosphorus in some form either organic, combined or oxidized. In muscle, it exists in the organic form in direct combination with the molecule, in the combined form as nucleins, nucleo-proteids, lecithin, protagon, and phospho-carnic acid and etc., and finally in oxidized or inorganic form as the phosphates of potassium, sodium, calcium, magnesium, and according to a few, aluminium.

The nature of the role which phosphorus plays in the animal body is as yet not positively known. The effect of its absence is quite apparent, and yet it is dependent upon the other constituents for its full value. Of the organic forms of phosphorus, lecithin is considered to be one of the intermediate products between the phosphates of plants and animals. In the vegetable life, the phosphates are partly changed into this body, and after consumption by animals it is then to a degree, transformed into the

mineral state. Lecithin has also an important nutritive function in helping to form the bony structure, and in building up a part of the tissues of the body - the chief of them being the brain, spinal cord and marrow. It is also said to serve as a reserve for the supply of food to broken down cells.

The preponderance of the evidence seems to lay stress upon the importance of the nucleins and their allied bodies and to show that the combined phosphorus of the animal body is to a great extent in chemical combination with the proteids. Of phospho-carnic acid, Siegfried states that it is closely allied to the nucleins. It is assimilated during muscular work, and hence seems to serve as a source of energy, and to be one of the decomposition products in the changing of the organic to the inorganic phosphorus.

Concerning the oxidized phosphorus, Leibig[7] in his early work showed that the mineral constituents of muscle were as essential to their structure as to the performance of their functions. It is an admitted fact that sodium phosphate is more abundant in the blood than in the cells, that the potassium salt occupies primarily the reciprocal position, and that the bony structure is abundant in the phosphate of calcium. Just what function these several mineral constituents play in cell life is as yet not positively known.

In general, it can be stated that the phosphorus content of vegetable life in its organic and inorganic forms is subject to variations. From the work which has been done upon the study of phosphorus in the germination of seeds,- the most recent of which is due to Iwanoff,[8] Zaleski,[9] Hart and Andrews,[10] and Schulze and Castoro,[11] - there is still some doubt as to how phosphorus

exists. Iwanoff and Zaleski found both organic and inorganic phosphorus in seeds, while Hart and Andrews, and Schulze and Castoro, by using their own methods, found only the organic phosphorus. Of these investigators, all but Hart and Andrews found upon germinating these seeds that they contained inorganic phorphorus, and that it increased upon further growth in the dark. Hart and Andrews also noted that the organic phosphorus increased decidedly in solubility during germination. Thus it can be seen that a study of the phosphorus content of muscle along these same lines may be of interest, may add some light to the nutritive value of meat, may aid in obtaining a further insight into the differences in the cuts of meat from the same animal and different animals, may show wherein the meat from the various breeds of animals differ, and may explain how the change of rations influences the quality of the meat.

HISTORICAL.

A brief review of all the work done upon the estimation and study of the phosphorus compounds in meat follows.

In 1807, Berzelius[12] first investigated the ash content of muscle. He noted the presence of sodium, magnesium and calcium phosphate. In 1832, Chevreul[13] again took up this work, studying the ash content of the extract of muscle. He found 81 per cent of the ash of muscle to be soluble in water, and of the insoluble portion, 5.8 per cent consisted of calcium phosphate and 13.2 per cent of magnesium phosphate.

For the next twenty years, considerable work was done along this line by Schlossberger,[14] Enderlin,[15] Stölzel,[16] Staffel,[17] Weber,[18] Lehmann,[19] and Echevarria[20], who studied the ash content of the muscular flesh of various animals. They in turn analyzed

this ash for its several components,- phosphorus being among them. During this period, Grohe[20a] investigated the constituents of frogs flesh, and found the organic and inorganic composition to be the same as other sorts of muscle. He estimated the quantity of inorganic phosphorus. Valencinnes and Fremy[20b] found large quantities of potassium acid phosphate in muscle and separated it as crystals by means of alcohol. They stated that creatinine was found in combination with phosphorus.

It was during this same period that Liebig's[21] valuable article appeared. In his study of the extract of flesh, he directed considerable attention to the nature of the inorganic phosphates. He found alkali phosphates in the ash from the extract, and these upon further examination proved to be portions of the mono-, di-, and tri-phosphates. He found that a water solution of this ash was strongly alkaline, and that after testing it with silver nitrate, the di- and tri-basic phosphates were present. Liebig also studied the acidity of the extract, stating that it was due to the acid salts of the alkalies with both phosphoric and lactic acids.- the former being chiefly of the di-basic salt. Liebig was the first to separate inosinic acid - an organic phosphorus compound. During the same period, Bibra[22] and Keller[23] both studied the water soluble ash of muscle, determining the percent of phosphorus. Keller, who worked under Liebig, found that 71.7 percent of the phosphorus in the ash of meat was soluble, and that 80 per cent of the total ash of the meat went into the extract.

Nothing further of import was done until 1873, when Bunge[24] made ash analysis of beef, and for the first time had his results calculated upon the basis of the fresh substance. Heretofore, all

analyses of the ash content of flesh had been made upon the ash itself, and calculated in percents of the same. In this same year, Pott[25] made an analysis of flesh meal and fresh meat. He determined the total phosphorus, and also made an extract with concentrated hydrochloric acid. In the solution, he found 0.366 percent phosphoric acid. In 1874, Mene[26] reported the results of his investigation in analyzing several cuts of beef, veal, mutton, and fresh and salted pork. In these he gave the percent of phosphorus. Two years later, Champion and Pellett[28] studied the relation of the bases to the acids in the ash of meat.

Jolly[29], in 1879, was the first to make a study of both muscle and tendon with the object of ascertaining the nature of the distribution of the phosphates. His experiments were made upon veal, fat beef, and lean beef. He found that fat beef muscle contained six times as much phosphorus as the lean; that there was no appreciable difference between the total phosphorus content of the tendon of the veal and that of the beef, and that the alkali phosphates, which belong to the blood, were more abundant in the veal tendon than the earthy phosphates. König[30], in 1880, reported the complete ash analysis of two kinds of fish, determining the total phosphorus. In 1882, Weyl and Zeitler[31] determined the phosphorus in normal and tetanized muscle of dogs. The phosphates increased in the latter while the lecithin remained practically unchanged, hence the difference was due to the breaking down of the nuclein of the muscle.

Lawes and Gilbert[32], in 1883, made analyses of beef, veal, pork and mutton, in which they determined the ash and in this the total phosphorus. During this same year, Kossel[33] studied the com-

position of the cell nucleus of various organs from different animals. He estimated the total phosphorus and also that existing as nuclein. In 1885, Bunge[34] again published the results of the analyses of the ash of two samples of beef muscle which had been freed from fat, tendon and veins. Atwater[35], in his work upon the chemistry of fish, determined the total phosphorus. In 1888, Kolpakcha[36] reported the total phosphorus content of three samples of meat, finding the ratio of P_2O_5 to nitrogen to be 1 : 7.3.

Following this came the work of Griffiths[37] upon the composition of the nervous tissue of invertebrates, and in this he estimated the percent of lecithin. In 1893, Whitfield[38], in a study of the chemistry of muscle, stated that he found myosin not to be a nucleo-albumin, and that muscle contained no nucleo-albumin. The next to touch upon this branch of the subject was Katz[39], in 1896. His work is considered to be the most complete and reliable up to the present time. He made an exhaustive study of the mineral content of muscular flesh, examining in all thirteen different kinds. In this work, he estimated, first, the total phosphorus soluble in hot water, and considered this to be the phosphates; second, that dissolved from these insoluble residues by alcohol, and designated this as lecithin; and third, that in the residues insoluble in both the water and alcohol, and considered it as nuclein. From this data, it can be concluded that about three-fourths of the phosphorus exists as phosphates, and that the lecithin content is about one and one-half times that of the nuclein. The following table shows his results in the cases of beef, veal and pork.

- See page 14 -

In 1897, Gautier[41] worked upon fresh and refrigerated beef and mutton. He determined the percentages of phosphorus soluble and insoluble in hot water. He also estimated the quantity of neucleinic acid. In this same year, Miss K. I. Williams[42] analyzed twenty-seven samples of cooked fish and one of oysters, in which the total phosphorus was determined.

In 1898, Wileys'[43] bulletin upon the chemical composition of the carcasses of pigs was published. In this he gave the percentages of lecithin for each cut. His maximum and minimum figures for animals of the same breed were 0.46 percent, 0.17 percent respectively, indicating that variation is not necessarily due to the kind of breed. Seigfried,[44] in 1899, published an article in which he gave the analysis of the muscle of a new born calf. He found 0.034 percent nuclein-phosphorus and 0.21 percent of total phosphorus.

At the same time, Macleods'[45] paper upon the comparative study of phosphorus in the muscle of rested and wearied dogs, appeared. The author made an extended study of the different forms of phosphorus existing in muscle, paying particular attention to the ratio of the inorganic and organic forms. He determined the total phosphorus in the meat, then made a water extract of another portion at 50^{0}-60^{0} C. In this he determined the total and inorganic phosphorus directly, and the organic phosphorus by difference. The nuclein-phosphorus was estimated in another portion of the extract. His conclusions were that the organic phosphorus of the extract was diminished by muscular work, that the inorganic phosphorus was conversely increased, and that the nuclein-phosphorus was decreased by excessive muscular work. The following table shows the results of his analysis:

RESULTS of KATZ and MACLEOD.

Table 4. - Forms of Phosphorus in Meat (Katz).

Table 5. - Forms of Phosphorus in Dog Flesh (Macleod).

Table 4

Forms of Phosphorus in Meat According to Katz.

Kind of Meat	Calculated to Fresh Basis: Water in Fresh Substance %	Total Phosphorus %	Water soluble %	Alcohol soluble %	Insoluble residue %	Calculated to Dry Basis: Total Phosphorus %	Water soluble %	Alcohol soluble %	Insoluble residue %
Beef	75.80	.170	.123	.028	.020	.709	.509	.117	.082
Veal	75.39	.220	.146	.042	.032	.893	.593	.172	.128
Pork	72.89	.213	.153	.037	.023	.785	.563	.136	.085

Table 5

Forms of Phosphorus in Dog Flesh According to Macleod

Description	Phosphorus: Soluble: Inorganic %	Organic %	Total %	Insoluble (Indigest) %	Total %
Rested dogs (ave. 6)	0.208	0.068	0.275	0.097	0.375
Fatigued dogs (ave. 4)	0.242	0.035	0.278	0.166	0.444
Average	0.225	0.047	0.277	0.132	0.410

During this year, Kruger[46] worked upon the separation of muscle nuclein with the idea of using a method based upon its insolubility in salt media. In 1902, Percival,[47] a pupil of Gautier, investigated the phosphorus content of muscle. He separated the three forms - mineral, combined and organic - in various animal organisms. His method of procedure was briefly as follows: The organs, after freeing from blood, were thoroughly ground and mixed. One portion was then taken for the estimation of total phosphorus. A second portion was treated with cold dilute hydrochloric acid for twenty-four hours, thus removing the phosphates. The residues from this treatment were next boiled with a 0.5 per cent hydrochloric acid solution in order to separate the lecithin, nucleins and etc., or the combined phosphorus. The total phosphorus was determined in each of these extracts and in the last insoluble residues, thereby obtaining the different forms of phosphorus. In muscle, the total phosphorus as P_2O_5 was 0.506 percent, the mineral phosphorus 0.217 percent, the combined 0.095 percent, and the organic 0.193 percent.

At the same time, Bonanni[48] compared the analyses of the muscle of dogs poisoned by veratrin with that of the normal animal. He determined the phospho-carnic acid present. Panella[49] estimated the quantity of phospho-carnic acid in muscle after death. In 1903, Baimakoff[50] reported the analyses of the muscle of ten children which had died from acute infections. In these he determined the total phosphorus. In 1905, Griffiths[51] published a second paper upon the chemistry of invertebrate muscle, in which he made a complete ash analysis, including the determination of total phosphorus.

PRELIMINARY WORK.

In undertaking this study, the first step in question was that of separating the soluble inorganic and organic forms of of phosphorus, and hence, a brief review of the most recent methods in use for this purpose will be of value.

As suggested above, Zaleski, Iwanoff, Hart and Andrews, and Schulze and Castoro studied this question in the case of germinated and ungerminated seeds.

Zaleski's procedure was that of using a 0.2 percent solution of hydrochloric acid as the extraction agent. In this extract, he determined the total soluble, the organic and the inorganic phosphorus. For this latter separation, he used the regular acid molybdate solution directly upon the extract, believing that none of the organic phosphorus compounds would be changed by the action of the free nitric acid, and consequently that only the phosphorus already oxidized would be thrown down. The organic phosphorus was obtained indirectly by subtracting the amount of inorganic determined directly, from the total soluble phosphorus.

Iwanoff used as his extracting agent a 1 percent acetic acid solution. In the extract, he determined the inorganic phosphorus directly by using the ordinary molybdate solution, just as Zaleski had done. He stated that the influence of the nitric acid, present in the acid molybdic solution, was insignificant, and that the organic matter did not interfere with the precipitation of the phosphates.

Hart and Andrews, however, claimed that the presence of the free nitric acid in the molybdic solution would cause a splitting off of some of the phosphorus from the organic compounds.

In this way, the inorganic phosphorus content would be unduly increased, and the organic form correspondingly decreased. They found this to be the case in nucleic acid from wheat bran. As a result, Hart and Andrews undertook to so modify the method that the errors would be reduced to a minimum. This they did by using a neutral solution of molybdic acid - made by neutralizing the usual solution with ammonia -. In conjunction with this, they used just enough free nitric acid to cause a separation of the ammonium phospho-molybdate compound. By applying this modified method to seeds and seedlings, entirely different results were obtained from those of Iwanoff and Zaleski. Instead of finding inorganic phosphorus in seeds and growing seedlings, they found these to contain practically no inorganic phosphorus, but primarily, only the organic form.

Schulze and Castoro took up a study of this question, bearing in mind the work of Iwanoff, Zaleski, and Hart and Andrews. They stated that the valuable work of the last named gentlemen might be at fault in that the inorganic phosphorus is not necessarily all precipitated, inasmuch as Grete[52] found that in the presence of organic matter considerable nitric acid must be added to obtain the separation of the phosphoric acid in the form of the molybdic compound. Their method of separating the inorganic phosphorus was as follows:- A 1 percent hydrochloric acid extract of the seeds was taken and treated with calcium chloride and ammonia. In this way, the inorganic phosphorus was precipitated as calcium phosphate. This salt was then filtered off, treated with ammonium citrate, and finally the filtrate from this solution with magnesia mixture - separating the phosphorus as ammonium magnesium

phosphate, in which form it was filtered, ignited, and weighed as the pyro-phosphate. From their work, Schulze and Castoro found, like Hart and Andrews, that the ungerminated seeds contained no inorganic phosphorus, on the other hand, they found, like Iwanoff and Zaleski, that germinated seed contained both the inorganic and organic forms of phosphorus.

In our work, we followed the method of Hart and Andrews, believing with them that the excess of free acid would cause the decomposition of some of the organic phosphorus compounds. In such complexed substances as meat, there can be no doubt but that the presence of such a strong mineral acid as nitric would cause serious changes to take place. Of course, these changes might not be the immediate cause of any transformation as regards the forms of phosphorus, but one would naturally expect that the ultimate result, due to such a foreign body, would cause a serious disturbance in the equilibrium of the organic and inorganic constituents. We, however, grant that the objection of Schulze and Castoro is, perhaps, correct to a limited extent, and in this work we have borne it in mind. The method, as finally adopted for determining the inorganic phosphorus, we fully realize does not necessarily produce a complete separation of the two forms of phosphorus, yet approaches as near to this point as possible - so near that the errors in question, if they exist, may be ignored, at least until a further knowledge of the composition of meat is known.

Aside from estimating the inorganic, the organic, and the total phosphorus in the water extract, we also determined the total phosphorus in the meat, and that in the insoluble residues. In connection with each of the experiments, the chemical composition

of both the meat and the water extract was also estimated. This included, in the case of the meat, the following determinations: Nitrogen, ash, moisture and fat; and in that of the water extract: Total nitrogen, proteid nitrogen, non-proteid nitrogen, non-nitrogenous extractives, nitrogenous extractives, ash and total solid matter. From the data to be thus obtained, it can readily be seen that there may be much of interest in a study of the relation of the forms of phosphorus to the other constituents in meat.

A brief outline of the methods as used in this laboratory and which pertain to this work, follow.

I. Preparation of Sample.

The cuts of meat were prepared as nearly as possible according to the general plan of the housewife. All the visible gristle, surplus fat, and any other refuse material, were removed, weighed and designated as trimmings. The bone was also carefully cut out and tared. The remaining edible meat was then weighed and put aside for the ordinary grinding.

GRINDING. - After cutting the piece of meat into small portions, it was passed through the chopper three times, mixing the ground sample thoroughly after each grinding. A part of the meat was then taken, bottled and properly labeled.

II. Direct Analysis.

The direct analysis of meat included the following determinations, made upon the fresh sample: Moisture, fat, ash, total nitrogen, and total phosphorus.

MOISTURE. - 1.5 to 1.8 grams of the sample were weighed in double duplicate into moisture tubes. Whenever the meat was

very fat, these tubes were partially filled with a coil of fat-free paper in order to insure against any loss of the fat. The weighed samples were then placed in a boiling water oven and heated for about twelve hours. After this, they were transferred to a glycerin oven, the temperature of which was 105° C., and heated until their weights were constant. Oxidation of the fat was prevented by having a current of dry hydrogen passing through the oven. The loss in weight represented the amount of moisture.

FAT. - The residues from the moisture determinations were extracted with anhydrous ether, using the Soxhlet apparatus in connection with the Hopkins condenser. The extractions were continued for twenty-four hours, after which the insoluble portions of the meat were removed, ground with ignited sand, replaced in the tubes and extracted for another twelve hours. When done, the ether was recovered, the fats dried at 103° C., and weighed until constant.

ASH. - 1.5 to 2.0 grams of the meat were weighed into tared crucibles, and then placed in a boiling water oven until most of the moisture was driven off. By this preliminary treatment, the spattering of the fat upon subsequent ignition of the meat was prevented. The crucibles were then transferred to the muffle and gradually heated until the meats were well charred, when the full flame was turned on and the ignition continued at red heat for two to three hours. The ash was then placed in desiccators and weighed in one to one and one-half hours.

TOTAL NITROGEN. - 1.2 to 1.5 grams of the meat were weighed out in double duplicate into Kjeldahl flasks. In order to aid in transferring the meat, the weighed samples were placed upon

folded filters, which were then dropped into the flasks. Sherman's modified Kjeldahl method was used throughout. To the meat, 25 c.c. of concentrated sulphuric acid was added, and then 0.7 grams of mercury. The mixture was gently heated upon the digestor until any frothing ceased and the mass became well charred. The heat was then removed, and after allowing the flasks to cool somewhat, 10 to 15 grams of powdered potassium sulphate were added. The digestion was then continued, and the time necessary for the liquid to become clear was noted, when it was allowed to run one and one-hours. The necks of the flasks were now washed down with ammonia-free distilled water, after which the oxidation was continued for another half hour, when it was complete. 250 c.c. of distilled water was then added to each flask, before the mass had cooled sufficiently to solidify. From this stage, the procedure was the same as given in the ordinary method.

TOTAL PHOSPHORUS. - About 5 grams of the sample were weighed in triplicate into Kjeldahl flasks, and 20 c.c. of concentrated sulphuric acid added. The mixture was cautiously heated until it became well charred. It was then allowed to cool slightly, when 5 to 10 grams of crystallized ammonium nitrate were carefully added. The digestion was continued at a low temperature at first, then gradually increased until the liquid boiled. When the mixture did not clear up within an hour, 5 grams more of the salt were added and the digestion continued. The oxidized mass was transferred with the aid of hot distilled water to beakers. Care was taken in not using too much water and in keeping the volume within 200 c.c.. When the solution was cold, it was neutralized with strong ammonia, using litmus paper as indicator; 5 grams

of ammonium nitrate were then added and the beaker placed upon the water bath. The temperature was allowed to rise to 60°C., when 100 c.c. of clear, acid ammonium molybdic solution was added while stirring the contents vigorously. The temperature was again raised to 60°C., and kept at this point for fifteen minutes. During this time, the mixture was stirred frequently. The yellow precipitate stood from one and a half to two hours at the room temperature, when the clear, supernatant liquid was decanted through filters. The precipitate was washed twice by decantation with ammonium nitrate solution and then transferred to the filter and again washed three times with the nitrate solution. The filtrate, if clear, was discarded. The yellow precipitate was dissolved with dilute ammonia and hot water and treated further in the usual manner for gravimetric estimation of phosphorus by the "magnesia mixture" method. The ammonium magnesium phosphate precipitate was dried, transferred to a tared crucible and ignited at a red heat for two to three hours. It was then removed and when cool, any lumps were carefully broken up, after which it was reheated for another hour, cooled and weighed. The resulting magnesium pyro-phosphate was calculated to phosphorus. In cases where the pyro-phosphate appeared to be contaminated, it was dissolved in hydrochloric acid and reprecipitated.

III. Preparation and Analysis of the Cold Water Extracts of Meats.

(A) Preparation of the Cold Water Extracts.

About 100 grams of the sample were weighed out in the following manner: first, three portions of 5 to 5 1/2 grams were

weighed into 100 c.c. beakers, then three portions of about 30 grams each were proportionally divided among five of the beakers, making in all eighteen lots. In each of these, about 5 c.c. of ammonia-free water was added, and the meat mixed with the aid of a glass rod into a thick paste. Then 50 c.c. more of the water was added and the whole thoroughly stirred for fifteen minutes. The insoluble portions were allowed to settle, when the supernatant liquids were decanted through their respective filters. Great care was taken to prevent the filtrates from dripping directly into the vessel below, as mechanical agitation causes some coagulation of the proteid. The residues were thoroughly drained and then treated further with 25 c.c. of distilled water, stirred for five minutes, allowed to settle and again filtered as above. This treatment was continued until the filtrates measured about 230 c.c., when they were combined and made up to 5000 c.c.. This cold water extract was then analyzed as follows: For total solid matter, ash, total nitrogen, proteid nitrogen, non-proteid nitrogen, nitrogenous extractives, non-nitrogenous extractives, total phosphorus, inorganic phosphorus, and organic phosphorus.

(B) Analysis of Cold Water Extracts.

I. TOTAL SOLIDS. - 100 c.c. portions were taken in duplicate and evaporated in platinum dishes upon a water bath. They were then placed in a water oven and dried until constant in weight. The gain in weight represented the total solid matter.

II. ASH. - The dried residues from the above determinations were carefully ignited at a very low red heat until the mineral matter became white. The ignition was repeated until the weight became constant. The residue left on ignition was the ash.

III. TOTAL NITROGEN. - 100 c.c. portions of the extract were digested in triplicate in the usual manner for nitrogen determination. The mercury was not added, however, until the liquid had evaporated far enough for acid fumes to come off. In this way, bumping and frothing were prevented. In the nitrogen work upon the water extracts, dilute standard solutions - about twelfth normal - were used. Corrections were made for the nitrogen in all the reagents.

IV. PROTEID NITROGEN. - In this study, the proteid nitrogen represents that found in the albumen, coagulated by heat in neutral solution, together with that in the albumoses separated by zinc sulphates, and that in the peptones from the tannin and salt treatment. This multiplied by 6.25 gave the proteids. These several constituents were determined in the following manner:

(a) Coagulated Nitrogen. - Portions of 200 c.c. in triplicate were evaporated in beakers upon the water bath to 40 c.c. They were then removed and carefully neutralized with alkali to litmus. The solutions were replaced upon the baths and heated for ten to fifteen minutes, when the separated proteid was filtered off and thoroughly washed with hot water. The coagulum was then analyzed for its nitrogen content in the usual manner. However, that which clung to the walls of the beaker was very carefully removed by the aid of hot concentrated sulphuric acid and hot water.

(b) Albumose Nitrogen. - The filtrates from the above determination were evaporated upon the water bath to about 25 c.c. They were then removed, 1 c.c. of 50 percent sulphuric acid was added to each, and then enough crystallized zinc sulphate to saturate the solution. After standing twenty-four hours, the separated

proteid was filtered off and washed with a saturated solution of zinc sulphate. The nitrogen was estimated in the precipitate and designated as that due to albumoses.

(c) Peptone Nitrogen. - Three portions of 200 c.c. each of the water extract were treated as in (a). The filtrates from these were transferred to 110 c.c. measuring flasks, and 5 c.c. each of solutions of salt and tannin were added. After mixing thoroughly, the flasks were filled to the upper mark with distilled water and again shaken. In twenty-four hours, the precipitated proteid was filtered off, using dry papers and flasks. A measured portion of the clear filtrate was analyzed for nitrogen. In this manner, it was supposed that the nitrogen thus obtained represented all of that due to non-proteids, and by subtracting this from the total nitrogen of the water extract, the total proteid nitrogen was obtained. Hence, the difference between the sum of the coagulable and albumose nitrogens, and the total proteid nitrogen was calculated to give that due to peptones.

V. NON-PROTEID NITROGEN. -- This was obtained by subtracting the total proteid nitrogen determined as just stated, from the total nitrogen in the extract. This multiplied by 3.12 gave the non-proteids.

VI. NITROGENOUS ORGANIC EXTRACTIVES. - These were obtained by multiplying the non-proteid nitrogen by 3.12.

VII. NON-NITROGENOUS ORGANIC EXTRACTIVES. - By subtracting the total mineral matter in the extract from the determinations of the total solids, the soluble organic matter was obtained. Then the sum of the proteid and the non-proteid gave the total nitrogenous organic matter. Hence, the difference between the total

organic matter and the nitrogenous organic matter gave that due to the non-nitrogenous, and for want of a better term, this was designated as non-nitrogenous organic extractives.

VIII. TOTAL PHOSPHORUS. - Portions of 250 c.c. were taken in triplicate and transferred to Kjeldahl flasks. 20 c.c. of concentrated sulphuric acid was added and the oxidation and further procedure was conducted as outlined under total phosphorus in meat.

IX. INORGANIC PHOSPHORUS. - Portions of 500 c.c. were taken in triplicate, and the determination was carried out as stated hereafter.

X. ORGANIC PHOSPHORUS. - This determination was obtained indirectly by subtracting the inorganic phosphorus as determined, from the total soluble phsophorus..

EXPERIMENTAL WORK UPON INORGANIC PHOSPHORUS.

A water extract of a sample of raw, lean beef round was made in the usual manner. Portions of 250 c.c. were taken in triplicate, and the Hart-Andrews method for estimating the inorganic phosphorus was followed very closely. The extract was neutralized to litmus with ammonia, 10 grams of crystallized ammonium nitrate were added, and the solution placed upon the water bath. When the temperature reached 65° C., 2 c.c. of nitric acid (sp.gr.1.20) was added, and this was followed by 50 c.c. of neutral molybdate solution. Immediately, a heavy yellow-green flocculent precipitate began to separate. After stirring several times, this settled out leaving a clear filtrate which was often of an emerald green color. The precipitate did not resemble the usual phospho-molybdic compound, either in color or in crystalline form. After standing two

hours at room temperature, the precipitate was filtered and washed with ammonium nitrate. It was then treated with dilute ammonia (2.5 percent) and hot water. It turned green at once, and was found to be partially insoluble. The solution was dark brown in color and not clear. The filtration was also quite slow. Upon neutralizing the solution with hydrochloric acid, a grayish flocculent precipitate came down. This was difficultly soluble in strong ammonia. In adding the magnesia mixture, the resulting precipitate was found to be flocculent and not of a characteristic nature.

After repeated attempts to use the Hart-Andrews method as outlined by them, it seemed necessary to introduce modifications before the method could be used with accuracy in separating inorganic from organic phosphorus in water extracts of meats. Accordingly, the first question which arose was whether the substance that apparently caused the trouble might not be removed. For, if a separation could be effected whereby the method would work and at the same time not cause any change in the forms of phosphorus, the result would be all that could be desired. Secondly, in conjunction with this step, the matter of determining the influence of varying amounts of free nitric acid was taken up, in order to ascertain its influence in aiding in the separation of the phosphorus, and consequently in overcoming the retarding action of the organic matter. Parallel with these tests, the action of varying amounts of the neutral molybdic solution was studied.

Two methods of procedure were used in attempting to remove the major part of the interfering organic matter - first, that of using precipitating reagents, and, second, that of coagulating the albumen by evaporation and the removal of the coagulum.

The precipitating reagents used were ammonium nitrate and neutral molybdic solution. In the first case, 25 c.c. of the molybdic solution was added to 250 c.c. of the cold neutral extract and stirred thoroughly. A grayish, flocculent precipitate separated out. After standing in the cold for two hours, the precipitate was filtered off and washed. The filtration was slow, and the washing quite difficult. The phosphorus was estimated in the precipitate by dissolving it in ammonia, and then following the usual "magnesia mixture" method.

As in the original method with the extract, upon neutralizing the ammonical solution, a flocculent precipitate separated. This was difficultly soluble even in strong ammonia. In each case some phosphorus was found in the separated organic matter. The filtrate, after removing the precipitate due to the molybdic solution, was heated upon the water bath to 65^{0} C., after having added 10 grams of ammonium nitrate. 2 c.c. of nitric acid was added and then another 25 c.c. portion of the neutral molybdic solution. Up to this time, nothing separated, but now a pale yellow, flocculent precipitate came down. This did not change in appearance on standing, and the addition of 25 c.c. more of the molybdic solution did not produce any visible effect. This precipitate was filtered, washed, and treated as usual for the estimation of phosphorus. The filtrate which was colored green was allowed to stand twelve hours. It was then heated to 65^{0} C., and 25 c.c. of neutral molybdic solution added. Nothing took place; then 1 c.c. of nitric acid was added. The green color changed to a yellow, and a slight precipitate began to form. Upon standing, it increased somewhat. After four hours, it was filtered, and the phosphorus determined in this

portion as in the first case. After the filtrate was allowed to stand twelve hours, a very slight precipitate was noticeable. The solution was again heated to 65°C., and treated with another cubic centimeter of acid. A very slight separation took place, which was so small that it was not considered to be weighable. However, it was filtered off and added to the last portion. This filtrate was treated with another cubic centimeter of acid, as in the preceding cases, but upon standing several hours, nothing further separated.

The ammonium nitrate procedure was followed exactly as in the case of the neutral molybdic solution, excepting that the three portions of the extract were first heated. To 250 c.c. of the extract, 10 grams of ammonium nitrate was added, and the solution heated at 65°C. for fifteen minutes. A flocculent, gray precipitate separated, and after standing several hours, it was filtered off and washed with ammonium nitrate. After several trials, it was found that the filtration and the washing would be more rapid if the solutions were warmed again, just previous to filtering. This precipitate was treated with ammonia and hot water, and the phosphorus estimated as usual. There was practically no phosphorus in combination with this organic matter. The filtrate was next heated to 65°C., 2 c.c. of nitric acid, and 50 c.c. of neutral molybdic solution then added. A flocculent, yellowish precipitate began to separate at once, and 5 grams more of ammonium nitrate was added to see if it would cause any change, but none was noticeable. On standing twenty minutes, a fine, yellow precipitate began to separate, and after three hours, it was filtered off. The filtration was rapid and the washing not difficult. In twelve hours, a trace of the yellow precipitate was noticeable. The filtrate was then

heated to 65° C., and 25 c.c. of neutral molybdate solution added. No apparent change took place, and the effect of 1 c.c. of the acid was noted. A slight yellow precipitate began to separate, and on standing it increased. After three hours, it was filtered, and the filtrate then allowed to stand twelve hours. No change was apparent, and the clear solution was again heated to 65° C., and treated with 1 c.c. of nitric acid. A very faint precipitate began to form, but after twelve hours, it was considered to be only a trace. No change was produced upon adding more acid.

The next procedure was to study the use of the method in the case of evaporating portions of the extract to small volumes, then filtering off the coagulable proteid matter, and testing the filtrates as in the two preceding cases. Portions of 500 c.c. were evaporated upon the water bath to about 50 c.c. They were then filtered while hot, and washed thoroughly with hot water. At first it was thought best to neutralize the solutions before filtering in order to hasten the filtration and bring down more of the proteid, but this step was not taken for fear of the change which might be produced upon the phosphorus.

The coagulum was oxidized in the usual manner, and tested for phosphorus. In all but one case, we found practically no phosphorus, and this was doubtless due to poor washing. However, in order to prove this point, three different lots of water extract, each measuring five liters, were evaporated to about 250 c.c., and then filtered. The filtrates were evaporated still further, and any coagulable matter separated and added to the main lot. The coagula were then oxidized, and treated quantitatively for phosphorus. In two cases, the amount found was 0.002 percent phosphorus, and in

the third case. 0.005 percent, calculated upon the basis of the fresh meat. It is evident from this that we need not consider the amount of phosphorus held mechanically or otherwise in the coagula.

The filtrate from the coagulum was made up to 200 c.c., and neutralized to litmus with ammonia. Ten grams of ammonium nitrate was added, and the solution heated to 65°C. 2 c.c. of nitric acid (1.20) and 50 c.c. of the neutral molybdic solution were then added. A very slight flocculent precipitate appeared at first, but this was followed by the characteristic yellow phospho-molybdum compound. This separation generally took place at once, leaving a clear, emerald green, supernatant liquid. On standing two hours, crystals, evidently of a double salt of ammonia and molybdic acid, formed and thus interfered somewhat with filtration and further manipulation. The filtrate was tested by heating it to 65°C., and adding more of the neutral molybdic solution. No change took place, and the effect of 1 c.c. of dilute nitric acid was noted. The green color disappeared, but otherwise there was no precipitate formed even after twelve hours. More acid produced no apparent change.

The following table gives a summary of this preliminary work, together with the results of applying the regular method upon the same samples. In all cases, the magnesium-pyro-phosphate was dissolved and reprecipitated.

Table 6

Summary of Preliminary Work
Inorganic Phosphorus

Laboratory No.	Method	A First Precipitate %	Filtrate from A: B 2cc. HNO_3 %	Filtrate from B: C 1 c.c. HNO_3 %	Filtrate from C: D 1 c.c. HNO_3 %	Filtrate from D: E 1cc. HNO_3 %	Total Inorganic Phosphorus %
1811	Hart	- -	.044	.062	none	none	.106
1815	Andrews	- -	.045	.052	trace	none	.097
1818	regular	- -	.110	.023	trace	none	.133
	Average (3)	- -	.066	.046	--	- -	.112
1811	Neutral molybdic solution	.015	.134	.024	trace	none	.173
1815		trace	.029	.070	trace	none	.099
1818		trace	.086	.022	trace	none	.108
	Average (3)	.005	.083	.039	- -	- -	.127
1811	Ammonium nitrate	none	.054	.073	trace	none	.127
1815		none	.049	.036	trace	none	.084
1818		trace	.089	.036	trace	none	.125
	Average (3)	--	.064	.048	--	--	.112
1788	Evaporation and Coagulation	none	.125	none	none	none	.125
1789		none	.102	none	none	none	.102
1811		.014	.097	none	none	none	.112
1815		none	.102	none	none	none	.102
1818		none	.111	none	none	none	.111
	Average (last 3)	- -	.103	--	--	--	.108

From a study of the averages of this table, it can be seen, first, that all four of the methods gave concordant results, especially is this true in the first, third, and fourth cases. Second, the precipitate resulting from the use of the neutral molybdic acid in the cold, and the ammonium nitrate in the hot, tends to carry down some phosphorus. This is more marked in the former case. With the evaporation method, sufficient proof has already been given to show that the coagulum does not contain any phosphorus. In the instance of No.1811, the filtration was slow, and the washing very difficult, and these facts help to explain the phosphorus content in this instance. Two other determinations, 1788 and 1789, are given to show further evidence of this fact. Third, the last method is apparently the only one of the four in which the phosphorus was completely thrown out by the one treatment of 2 c.c. of the dilute nitric acid and 50 c.c. of the neutral molybdic solution. In the other cases, the separation was not sharp and the precipitate was always decidedly flocculent and of a peculiar color. The separation was not as rapid, and the washing was generally slower. Fourth, it seems that an increase in the amount of nitric acid recommended by Hart and Andrews will overcome the influence of the organic matter in retarding the precipitation of the phosphorus, and that a moderate excess of acid will cause no further separation, showing that a great part of the phosphorus is held in solution and is not subject to as rapid change as one would expect.

As a result, it was decided to introduce into the method the modification of evaporating the extract, removing the coagulum, and working upon the resulting filtrate. Accordingly, a further study of the method was made, with the idea, first of improving it,

and second, of showing what form of phosphorus would be precipitated by this treatment. It was found that there was an advantage to be gained in diluting the filtrate from the coagulum to 250 c.c., and also in not allowing the solution to become cold while the yellow precipitate was settling out. In this way the molybdum salt was kept in solution. An effort was also made to do away with the tedious process of dissolving the pyro-phosphate and reprecipitating the phosphorus, which is, of course, necessary when there is any tendency toward reduction from organic matter.

The yellow precipitate was dissolved in the usual manner, with ammonia and hot water. The solution was then neutralized with nitric acid and diluted to 200 c.c. To this, 5 grams of ammonium nitrate was added, and the solution heated to 60^{0} C.; 20 c.c. of neutral molybdic solution was poured in, and then, while stirring vigorously, 5 c.c. of concentrated nitric acid was added. The yellow precipitate came down at once without any apparent contamination with organic matter. The filtration was rapid, and the filtrate very clear.

This procedure was tested by making parallel determinations with the official method, dissolving the phosphate and etc. The following table gives the results of these determinations.

Table 7

Percentage of Inorganic Phosphorus

Laboratory No.	Kind of Meat	Official method: Before dissolving %	Official method: After dissolving %	Modified method %
1837_1	Beef, rib, roast	.095	.087	.089
1837_2	do	.095	.091	.088
1837_3	do	.097	.089	--
	Average (3)	.096	.089	.089
1838_1	Beef, rib, roast	.146	.106	----
1838_2	do	.122	.106	.104
1838_3	do	.118	.102	.104
	Average (3)	.128	.104	.104
	Average (6)	.112	.097	.097

It will be seen by referring to the table, that there is practically no difference in the results, and inasmuch as the modification made the work much simpler and a great deal shorter, it has been used throughout. However, it should be stated that when the ignited pyro-phosphate was colored yellow, it was dissolved and treated as usual.

Finally, it was decided that the use of 3 c.c. of the dilute nitric acid instead of 2 c.c., be adopted. In this way, the objection of Schulze and Castoro might be met in part, although we have already shown that an extra amount of acid does not produce any change, and that the small amount used was sufficient for a complete separation.

The method as now in use is as follows: 500 c.c. portions of the water extract are taken in triplicate and evaporated upon the water bath to 50 c.c. The coagulum is then filtered off and washed with hot water until the washings and filtrate reach about 150 c.c. The filtrates, which were always found to be but very slightly acid, were treated with 10 grams of ammonium nitrate, then transferred to the water bath and heated to 60° C. At this point, 3 c.c. of nitric acid (1.20) was added, and this followed by 50 c.c. of clear neutral molybdic solution. The solution was stirred vigorously, and allowed to stand on the water bath for fifteen minutes at 60° C. During this period, it was stirred frequently. The beakers were then removed and put in a warm place for two hours. At the end of this period, the precipitate was filtered off and washed with ammonium nitrate as in the determination of total phosphorus. The ammonical solution of the precipitate was sometimes colored blue, but this disappeared after being heated upon the water bath

for a few minutes. It was then neutralized with nitric acid, and diluted with distilled water to 200 c.c. From this point, the procedure was as stated on page 27.

EXPERIMENTAL WORK IN DETERMINING THE PHOSPHORUS CONTENT OF MEATS.

The methods as already outlined for estimating the different forms of phosphorus have been applied, in most cases, in conjunction with other experiments in progress in this laboratory. As a result, we have had access to considerable data, regarding the complete composition of the meats, which we would otherwise not have been able to obtain.

In this way, the conclusions drawn from the phosphorus data have at times been materially reinforced as regards the composition of both the raw and cooked meats, the methods of cooking, the losses in cooking, and the accuracy of the methods for separating the different forms of phosphorus.

CHEMICAL COMPOSITION OF RAW MEATS.

Table 8. - Calculated to Fresh Basis.

Table 9. - Calculated to Water-free Basis.

Table 10. - Calculated to Water and Fat-free Basis.

Table 8

Chemical Composition of Raw Meat
Calculated to Fresh Substance

Laboratory No.	Kind of Meat	Water %	Total dry matter (Direct) %	Fat %	Proteid: Soluble %	Proteid: Insoluble %	Proteid: Total %	Organic Extractives: Nitrogenous %	Organic Extractives: Non-nitrogenous %	Organic Extractives: Total %	Ash: Soluble %	Ash: Insoluble %	Ash: Total %	Nitrogen: Soluble: Proteid %	Nitrogen: Soluble: Non-proteid %	Nitrogen: Soluble: Total %	Nitrogen: Insoluble %	Nitrogen: Total %
1788	Beef round, raw	73.42	27.40	3.15	2.42	17.96	20.38	1.23	1.55	2.78	.87	.22	1.09	.3868	.3930	.7798	2.8732	3.6530
1789	do	74.53	26.10	3.59	2.42	16.35	18.77	1.13	1.55	2.68	.95	.11	1.06	.3865	.3615	.7480	2.6170	3.3650
1823	do	75.61	24.41	2.14	2.42	15.97	18.39	1.26	1.54	2.80	1.00	.08	1.08	.3864	.4021	.7885	2.5555	3.3440
1828	do	75.69	24.95	2.52	2.21	16.40	18.61	1.20	1.56	2.76	.94	.12	1.06	.3539	.3838	.7377	2.6243	3.3620
1849	do	74.22	26.29	2.46	2.97	16.61	19.58	1.29	1.86	3.15	.99	.11	1.10	.4758	.4126	.8884	2.6566	3.5450
1850	do	74.89	25.26	2.24	2.93	15.67	18.60	1.34	2.00	3.34	.99	.09	1.08	.4689	.4309	.8998	2.5062	3.4060
	Average (6)	74.73	25.74	2.68	2.57	16.49	19.06	1.24	1.68	2.92	.96	.12	1.08	.4097	.3973	.8070	2.6388	3.4458
1853	Veal shank raw	75.08	25.44	3.03	2.07	17.39	19.46	.74	1.19	1.93	.66	.36	1.02	.3310	.2377	.5687	2.7823	3.3510
1854	do chuck do	72.93	27.98	6.33	1.81	16.71	18.52	.82	1.31	2.13	.67	.33	1.00	.2901	.2635	.5536	2.6734	3.2270
1855	do ribs do	68.38	31.91	12.09	1.74	14.64	16.38	.98	1.49	2.47	.67	.30	.97	.2779	.3125	.5904	2.3436	2.9340
1856	do ribs & shoulder do	71.00	29.29	8.57	1.88	15.43	17.31	.93	1.44	2.37	.74	.30	1.04	.3006	.2982	.5988	2.4682	3.0670
1857	do breast do	63.34	36.65	16.66	1.79	15.10	16.89	.78	1.42	2.20	.66	.24	.90	.2863	.2504	.5367	2.4163	2.9530
1858	do loin do	68.08	31.40	10.95	1.79	15.24	17.03	.98	1.46	2.44	.74	.24	.98	.2866	.3135	.6001	2.4389	3.0390
1859	do flank do	64.18	36.38	16.13	1.84	15.38	17.22	.92	1.16	2.08	.78	.17	.95	.2937	.2952	.5889	2.4611	3.0500
1860	do leg do	73.40	26.04	3.76	1.83	16.28	18.11	1.21	1.87	3.08	.89	.20	1.09	.2924	.3866	.6790	2.6050	3.2840
1861	do hind shank do	73.36	27.24	5.03	1.94	16.84	18.78	.98	1.42	2.40	.76	.27	1.03	.3110	.3147	.6257	2.6943	3.3200
	Average (9)	69.97	30.26	9.17	1.85	15.89	17.74	.93	1.42	2.35	.73	.27	1.00	.2966	.2969	.5935	2.5426	3.1361

Table 9

Chemical Composition of Raw Meat
Calculated to Water-free Basis

Laboratory No.	Kind of Meat	Total dry matter (Direct)	Fat	Proteid			Organic Extractives			Ash			Nitrogen				
				Soluble	Insoluble	Total	Nitrogenous	Non-nitrogenous	Total	Soluble	Insoluble	Total	Soluble			Insoluble	Total
													Proteid	Non-proteid	Total		
		%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
1788	Beef, round, raw	100.00	11.50	8.83	65.55	74.38	4.49	5.65	10.15	3.18	.80	3.98	1.412	1.434	2.846	10.486	13.332
1789	do	100.00	13.75	9.27	62.65	71.92	4.33	5.94	10.27	3.64	.42	4.06	1.481	1.385	2.866	10.027	12.893
1823	do	100.00	8.77	9.91	65.42	75.33	5.16	6.31	11.47	4.10	.33	4.42	1.583	1.647	3.230	10.467	13.699
1828	do	100.00	10.10	8.86	65.73	74.59	4.81	6.25	11.06	3.77	.48	4.25	1.418	1.538	2.957	10.518	13.475
1849	do	100.00	9.36	11.30	63.18	74.48	4.91	7.07	11.98	3.76	.42	4.18	1.810	1.569	3.379	10.105	13.484
1850	do	100.00	8.87	11.60	62.03	73.63	5.30	7.92	13.22	3.92	.36	4.28	1.856	1.706	3.562	9.922	13.484
	Average (6)	100.00	10.39	9.96	64.10	74.06	4.83	6.53	11.36	3.73	.47	4.20	1.593	1.547	3.140	10.255	13.395
1853	Veal, shank, raw	100.00	11.91	8.14	68.36	76.49	2.91	4.68	7.59	2.59	1.42	4.01	1.301	.934	2.235	10.937	13.172
1854	do chuck do	100.00	22.62	6.47	59.72	66.19	2.93	4.68	7.61	2.39	1.18	3.57	1.037	.942	1.979	9.554	11.533
1855	do ribs do	100.00	37.89	5.45	45.88	51.33	3.07	4.67	7.74	2.10	.94	3.04	.871	.979	1.850	7.344	9.194
1856	do ribs & shoulder do	100.00	29.26	6.42	52.68	59.10	3.18	4.92	8.10	2.53	1.02	3.55	1.026	1.018	2.044	8.427	10.471
1857	do breast do	100.00	45.45	4.88	41.20	46.08	2.13	3.87	6.00	1.81	.65	2.46	.781	.683	1.464	6.593	8.057
1858	do loin do	100.00	34.87	5.70	48.54	54.24	3.12	4.65	7.77	2.36	.76	3.12	.913	.998	1.911	7.767	9.678
1859	do flank do	100.00	44.34	5.06	42.28	47.34	2.53	3.19	5.72	2.14	.47	2.61	.807	.811	1.619	6.765	8.384
1860	do leg do	100.00	14.44	7.03	62.52	69.55	4.65	7.18	11.83	3.42	.77	4.19	1.123	1.485	2.608	10.003	12.611
1861	do hind shank do	100.00	18.47	7.12	61.82	68.94	3.60	5.21	8.81	2.79	.99	3.78	1.142	1.155	2.297	9.891	12.188
	Average (9)	100.00	28.81	6.25	53.67	59.92	3.13	4.78	7.91	2.46	.91	3.37	1.000	1.001	2.001	8.586	10.587

Table 10

Chemical Composition of Raw Meat
Calculated to Water- and Fat-free Basis

Laboratory No.	Kind of Meat	Total dry matter (direct)	Proteid			Organic Extractives			Ash			Nitrogen				
			Soluble	Insoluble	Total	Nitrogenous	Non-nitrogenous	Total	Soluble	Insoluble	Total	Soluble			Insoluble	Total
												Proteid	Non-proteid	Total		
		%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
1788	Beef, round, raw	100.00	9.98	74.06	84.04	5.07	6.39	11.46	3.59	.90	4.49	1.595	1.621	3.216	11.848	15.064
1789	do	100.00	10.75	72.63	83.38	5.02	6.89	11.91	4.22	.49	4.71	1.717	1.606	3.323	11.626	14.949
1823	do	100.00	10.87	71.71	82.58	5.66	6.92	12.58	4.49	.36	4.85	1.735	1.806	3.541	11.475	15.016
1828	do	100.00	9.85	73.12	82.97	5.35	6.95	12.30	4.19	.54	4.73	1.578	1.711	3.289	11.700	14.989
1849	do	100.00	12.46	69.70	82.16	5.41	7.81	13.22	4.15	.46	4.62	1.997	1.732	3.728	11.148	14.876
1850	do	100.00	12.73	68.07	80.80	5.82	8.69	14.51	4.30	.39	4.69	2.037	1.872	3.909	10.887	14.796
	Average (6)	100.00	11.11	71.55	82.66	5.39	7.27	12.66	4.16	.52	4.68	1.777	1.724	3.501	11.447	14.948
1853	Veal, shank, raw	100.00	9.24	77.60	86.84	3.30	5.31	8.61	2.94	1.61	4.55	1.477	1.061	2.538	12.415	14.953
1854	do chuck do	100.00	8.36	77.18	85.54	3.79	6.05	9.84	3.09	1.52	4.62	1.340	1.217	2.557	12.348	14.905
1855	do ribs do	100.00	8.78	73.86	82.64	4.94	7.52	12.46	3.38	1.51	4.89	1.402	1.577	2.979	11.824	14.803
1856	do ribs & shoulder do	100.00	9.07	74.47	83.54	4.49	6.95	11.44	3.57	1.45	5.03	1.451	1.439	2.890	11.912	14.802
1857	do breast do	100.00	8.95	75.54	84.49	3.90	7.11	11.01	3.30	1.20	4.50	1.432	1.253	2.685	12.088	14.773
1858	do loin do	100.00	8.75	74.52	83.27	4.79	7.14	11.93	3.62	1.17	4.79	1.402	1.533	2.935	11.926	14.861
1859	do flank do	100.00	9.09	75.95	85.04	4.54	5.73	10.27	3.85	.84	4.69	1.450	1.458	2.908	12.154	15.062
1860	do leg do	100.00	8.21	73.07	81.28	5.43	8.39	13.82	3.99	.90	4.89	1.313	1.735	3.048	11.692	14.740
1861	do hind shank do	100.00	8.74	75.82	84.56	4.41	6.39	10.81	3.42	1.22	4.64	1.400	1.417	2.817	12.131	14.948
	Average (9)	100.00	8.80	75.33	84.13	4.40	6.73	11.13	3.46	1.27	4.73	1.407	1.410	2.817	12.055	14.872

CHEMICAL COMPOSITION OF COOKED MEATS.

Table 11. - Calculated to Fresh Basis.

Table 12. - Calculated to Water-free Basis.

Table 13. - Calculated to Water and Fat-free Basis.

Table 11 Chemical Composition of Cooked Meat
Calculated to Fresh Substance

Laboratory No.	Kind of Meat	Water	Total dry matter (Direct)	Fat	Proteid			Organic Extractives			Ash			Nitrogen				
					Soluble	Insoluble	Total	Nitrogenous	Non-nitrogenous	Total	Soluble	Insoluble	Total	Soluble Proteid	Soluble Non-proteid	Soluble Total	Insoluble	Total
		%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
1801	Beef, round, boiled	61.26	39.69	3.54	.14	34.43	34.57	.48	.52	1.00	.34	.24	.58	.0220	.1549	.1769	5.5091	5.6860
1807	do do do	64.44	36.35	2.97	.25	31.67	31.92	.44	.53	.97	.31	.18	.49	.0394	.1422	.1816	5.0674	5.2490
	Average (2)	62.85	38.02	3.26	.20	33.05	33.25	.46	.53	.99	.33	.21	.54	.0307	.1486	.1793	5.2882	5.4675
1808	Beef, round, boiled	61.70	39.80	3.65	.33	33.45	33.78	.47	.54	1.01	.42	.14	.56	.0532	.1506	.2038	5.3512	5.5550
1802	do do do	59.54	41.44	3.92	.18	35.65	35.83	.48	.64	1.12	.31	.26	.57	.0286	.1537	.1823	5.7037	5.8860
	Average (2)	60.62	40.22	3.79	.26	34.55	34.81	.48	.59	1.07	.37	.20	.57	.0409	.1522	.1931	5.0274	5.7205
1824	Beef, round, boiled	55.96	44.60	8.47	.40	33.01	33.41	.83	1.06	1.89	.62	.21	.83	.0387	.2659	.3046	5.3064	5.6110
1809	do do do	66.61	40.12	3.53	1.04	33.72	34.76	.57	.64	1.21	.44	.18	.62	.1661	.1811	.3472	5.3948	5.7420
1803	do do do	58.94	41.62	3.60	.52	35.68	36.20	.53	.69	1.22	.42	.18	.60	.0827	.1707	.2534	5.7096	5.9630
	Average (3)	58.50	42.11	5.20	.65	34.14	34.79	.64	.80	1.44	.49	.19	.68	.0958	.2059	.3017	5.4703	5.7720
	Average (7)	60.35	40.40	4.24	.41	33.94	34.35	.54	.66	1.20	.41	.20	.61	.0615	.1742	.2357	5.4346	5.6703
1825	Beef, round, pot-roast	56.92	44.35	5.58	.37	34.32	34.69	1.31	1.53	2.84	1.03	.21	1.24	.0593	.4190	.4783	5.4907	5.9690
1829	do do do	57.57	42.85	4.20	.46	35.14	35.60	1.01	1.09	2.10	.68	.27	.95	.0733	.3220	.3953	5.6227	6.0180
1830	do do do	61.65	38.80	4.79	.41	31.06	31.47	.85	.95	1.80	.54	.20	.74	.0652	.2713	.3365	4.9695	5.3060
	Average (3)	58.71	42.00	4.86	.41	33.51	33.92	1.06	1.19	2.25	.75	.23	.98	.0659	.3375	.4034	5.3609	5.7643
1831	Beef, rib, 4th, roast	44.78	55.08	36.84	.52	15.30	15.82	.77	.82	1.59	.65	.18	.83	.0824	.2476	.3300	2.4490	2.7790
1833	do rib 3d & 4th do	47.33	52.33	32.11	.57	16.84	17.41	.86	1.15	2.01	.65	.15	.80	.0928	.2750	.3678	2.6922	3.0600
1837	do do do	53.33	47.07	25.21	.48	18.56	19.04	.91	1.02	1.93	.77	.12	.89	.0759	.2912	.3671	2.9709	3.3380
1838	do do do	49.73	50.67	27.79	.38	19.65	20.03	.91	1.04	1.95	.71	.19	.90	.0600	.2920	.3520	3.1440	3.4960
1840	do do do	42.35	58.07	37.16	.33	18.04	18.37	.80	.97	1.77	.66	.11	.77	.0523	.2563	.3086	2.8874	3.1960
1848	do do do	Lost	--	Lost	.36	21.47	21.83	1.06	1.19	2.25	.83	.20	1.03	.0583	.3398	.3981	3.4339	3.8320
1842	do do do	45.73	54.64	35.19	.31	16.44	16.75	.85	.97	1.82	.67	.21	.88	.0500	.2707	.3207	2.6303	2.9510
1844	do do do	42.15	58.25	34.42	.27	20.65	20.92	.89	1.01	1.90	.70	.31	1.01	.0430	.2841	.3271	3.3039	3.6310
1846	do do do	45.63	55.10	27.60	.25	23.59	23.84	1.09	1.51	2.60	.44	.62	1.06	.0398	.3504	.3902	3.7748	4.1650
	Average (9)	46.38	53.90	32.04	.39	18.94	19.33	.90	1.08	1.98	.68	.23	.91	.0616	.2897	.3513	3.0318	3.3831

Table 12 Chemical Composition of Cooked Meat
Calculated to Water-free Basis

Laboratory No.	Kind of Meat	Total dry matter (Direct) %	Fat %	Proteid			Organic Extractives			Ash			Nitrogen				
				Soluble %	Insoluble %	Total %	Nitrogenous %	Non-nitrogenous %	Total %	Soluble %	Insoluble %	Total %	Soluble Proteid %	Soluble Non-proteid %	Soluble Total %	Insoluble %	Total %
1801	Beef, round, boiled	100.00	8.92	.35	86.75	87.10	1.21	1.31	2.52	.86	.60	1.46	.056	.390	.446	13.880	14.326
1807	do do do	100.00	8.17	.69	87.13	87.81	1.21	1.46	2.67	.85	.50	1.35	.108	.391	.500	13.940	14.440
	Average (2)	100.00	8.55	.52	86.94	87.46	1.21	1.39	2.60	.86	.55	1.41	.082	.391	.473	13.910	14.383
1808	Beef, round, boiled	100.00	9.36	.85	85.77	86.62	1.21	1.38	2.59	1.08	.36	1.44	.136	.386	.522	13.721	14.243
1802	do do do	100.00	9.46	.44	86.03	86.46	1.16	1.54	2.70	.75	.63	1.38	.069	.371	.440	13.764	14.204
	Average (2)	100.00	9.41	.65	85.89	86.54	1.19	1.46	2.65	.92	.49	1.41	.103	.379	.481	13.743	14.224
1824	Beef, round, boiled	100.00	18.99	.90	74.01	74.91	1.86	2.38	4.24	1.39	.47	1.86	.087	.596	.683	11.898	12.581
1809	do do do	100.00	8.80	2.59	84.05	86.64	1.42	1.60	3.02	1.10	.45	1.55	.414	.451	.865	13.447	14.312
1803	do do do	100.00	8.65	1.25	85.73	86.98	1.27	1.66	2.93	1.01	.43	1.44	.199	.410	.609	13.718	14.327
	Average (3)	100.00	12.15	1.58	81.26	82.84	1.52	1.88	3.40	1.17	.45	1.62	.233	.486	.719	13.021	13.740
	Average (7)	100.00	10.34	1.01	84.21	85.22	1.33	1.62	2.95	1.01	.49	1.50	.153	.428	.581	13.481	14.062
1825	Beef, round, pot roast	100.00	12.58	.83	77.39	78.22	2.95	3.45	6.40	2.32	.48	2.80	.134	.945	1.079	12.380	13.459
1829	do do do	100.00	9.80	1.07	82.01	83.08	2.36	2.54	4.90	1.59	.63	2.22	.171	.751	.922	13.122	14.044
1830	do do do	100.00	12.35	1.06	80.05	81.11	2.19	2.45	4.64	1.40	.51	1.91	.168	.699	.867	12.808	13.675
	Average (3)	100.00	11.58	.99	79.81	80.80	2.50	2.81	5.31	1.77	.54	2.31	.158	.798	.956	12.770	13.726
1831	Beef, rib, 4th, roast	100.00	66.88	.94	27.78	28.72	1.40	1.49	2.89	1.18	.33	1.51	.150	.450	.600	4.445	5.045
1833	do 3&4th do	100.00	61.26	1.09	32.18	32.27	1.64	2.19	3.83	1.24	.29	1.53	.177	.526	.703	5.145	5.848
1837	do do do	100.00	53.54	1.02	39.43	40.45	1.93	2.17	4.10	1.64	.25	1.89	.161	.619	.780	6.312	7.092
1838	do do do	100.00	54.85	.75	38.78	39.53	1.80	2.05	3.85	1.40	.38	1.78	.118	.576	.694	6.205	6.899
1840	do do do	100.00	63.99	.57	31.07	31.64	1.38	1.67	3.05	1.14	.19	1.33	.090	.441	.531	4.973	5.504
1842	do do do	100.00	64.43	.57	30.09	30.66	1.56	1.77	3.33	1.23	.38	1.61	.092	.495	.587	4.814	5.401
1844	do do do	100.00	59.09	.46	35.45	35.91	1.53	1.74	3.27	1.20	.53	1.73	.074	.488	.562	5.672	6.234
1846	do do do	100.00	50.09	.45	42.81	43.27	1.98	2.74	4.72	.80	1.13	1.93	.072	.636	.708	6.851	7.559
	Average (8)	100.00	59.27	.73	34.70	35.43	1.65	1.98	3.63	1.23	.43	1.66	.117	.529	.646	5.552	6.198

Table 13 Chemical Composition of Cooked Meat
Calculated to Water- and Fat-free Basis

Laboratory No.	Kind of Meat	Total dry matter (Direct)	Proteid: Soluble %	Proteid: Insoluble %	Proteid: Total %	Organic Extractives: Nitrogenous %	Organic Extractives: Non-nitrogenous %	Organic Extractives: Total %	Ash: Soluble %	Ash: Insoluble %	Ash: Total %	Nitrogen: Soluble: Proteid %	Nitrogen: Soluble: Non-proteid %	Nitrogen: Soluble: Total %	Nitrogen: Insoluble %	Nitrogen: Total %
1801	Beef, round, boiled	100.00	.39	95.24	95.63	1.33	1.44	2.77	.94	.66	1.60	.061	428	.489	15.240	15.729
1807	do do do	100.00	.75	94.88	95.63	1.32	1.59	2.91	.93	.54	1.47	.118	.426	.544	15.181	15.725
	Average (2)	100.00	.57	95.06	95.63	1.33	1.51	2.84	.94	.60	1.54	.090	.427	.517	15.210	15.727
1808	Beef, round, boiled	100.00	.93	94.63	95.56	1.33	1.53	2.86	1.19	.40	1.58	.150	.426	.576	15.138	15.714
1802	do do do	100.00	.48	95.02	95.50	1.28	1.71	2.99	.83	.69	1.52	.076	.410	.486	15.202	15.688
	Average (2)	100.00	.72	94.81	95.53	1.31	1.62	2.93	1.01	.54	1.55	.113	.418	.531	15.170	15.701
1824	Beef, round, boiled	100.00	1.11	91.36	92.47	2.30	2.93	5.23	1.72	.58	2.30	.107	.736	.843	14.687	15.530
1809	do do do	100.00	2.84	92.16	95.00	1.56	1.75	3.31	1.20	.49	1.69	.454	.495	.949	14.744	15.693
1803	do do do	100.00	1.37	93.84	95.21	1.40	1.81	3.21	1.10	.48	1.58	.218	.449	.667	15.017	15.684
	Average (3)	100.00	1.77	92.46	94.23	1.75	2.17	3.92	1.34	.52	1.86	.260	.560	.820	14.816	15.636
	Average (7)	100.00	1.12	93.88	95.00	1.50	1.82	3.32	1.13	.55	1.68	.169	.481	.650	15.030	15.680
1825	Beef, round, pot roast	100.00	.96	88.52	89.48	3.38	3.95	7.33	2.66	.54	3.20	.153	1.081	1.234	14.162	15.396
1829	do do do	100.00	1.19	90.92	92.11	2.61	2.82	5.43	1.76	.70	2.46	.190	.833	1.023	14.548	15.571
1830	do do do	100.00	1.21	91.33	92.54	2.50	2.79	5.29	1.59	.59	2.18	.191	.798	.989	14.612	15.601
	Average (3)	100.00	1.12	90.26	91.38	2.83	3.19	6.02	2.00	.61	2.61	.178	.904	1.082	14.441	15.523
1831	Beef, rib, 4th, roast	100.00	2.85	83.88	86.73	4.22	4.50	8.72	3.56	.99	4.55	.452	1.357	1.809	13.427	15.236
1833	do, rib, 3d & 4th, do	100.00	2.82	83.28	86.10	4.25	5.69	9.94	3.21	.75	3.96	.459	1.360	1.819	13.315	15.134
1837	do do do	100.00	2.20	84.90	87.10	4.16	4.67	8.83	3.52	.55	4.07	.347	1.332	1.679	13.591	15.270
1838	do do do	100.00	1.66	89.88	91.54	3.98	4.54	8.52	3.10	.83	3.93	.262	1.276	1.538	13.741	15.279
1840	do do do	100.00	1.58	86.28	87.86	3.83	4.64	8.46	3.15	.53	3.68	.250	1.226	1.476	13.809	15.285
1842	do do do	100.00	1.59	84.52	86.12	4.37	4.99	9.36	3.44	1.08	4.52	.257	1.392	1.649	13.523	15.172
1844	do do do	100.00	1.13	86.66	87.79	3.73	4.24	7.97	2.94	1.30	4.24	.180	1.192	1.372	13.865	15.237
1846	do do do	100.00	.91	85.78	86.69	3.96	5.49	9.45	1.60	2.25	3.85	.145	1.274	1.419	13.726	15.145
	Average (8)	100.00	1.84	85.65	87.49	4.06	4.85	8.91	3.07	1.03	4.10	.294	1.301	1.595	13.624	15.219

DISCUSSION OF RESULTS.

In discussing the results, the general plan has been to arrange the tables so as to consider first the raw meats, including the beef round and the veal, and second the cooked meats, including the boiled, the pot-roasted and the oven-roasted. In making our statements, it must be born in mind that, in the main, we can, at the present time, base our conclusions only upon averages. As far as the present information upon the subject of flesh extends, we know that the breed, feed, and etc., of an animal have some influence upon the quality of the meat, and it is evident that a comparison of individual cases cannot be made when this data is lacking.

A few general statements concerning the raw meats should be made. The cuts of beef round were obtained from animals one to two years old, which had been fed upon grass, hay and corn. The cuts of veal were from the same animal which was four weeks and two days old. Regarding the meat used for cooking, the beef round was of the same type as that for the raw analysis, in fact, in a few cases it was from the same sample. The beef rib cuts were from animals two to three years old.

In connection with the cooked meats, it will be of interest in following the interpretation of the results, to explain briefly the methods of cooking, and give a few general deductions from the data in tables Nos. 11-13, which give the chemical composition of these meats calculated to the fresh basis, water-free basis, and water and fat-free basis.

First, as regards the method of cooking by boiling, the meat was cut into three-fourth inch cubes, then thoroughly mixed,

and portions of 1000 grams weighed off. The remainder of the meat was taken for the analysis of the raw sample. The weighed amount was placed in 200 c.c. of distilled water, the temperature of which varied according to the manner of boiling. At the end of the cooking, the meat was immediately removed from the liquid, and after allowing sufficient time for it to cool, it was again weighed in order to obtain the loss due to the cooking. The meat was then sampled and ready for analysis. The results were calculated upon the basis of the cooked meat.

It might be noted here that in the tables Nos. 11-13, the meat for laboratory Nos. 1801, 1807, 1808, 1802, 1809 and 1803 was from the same sample throughout, thus permitting a comparison of the methods of boiling as regards temperature and time.

Pot-roasting is what might be designated as dry boiling. In this, the meat is at first browned in a small amount of fat. It is then put in a pot containing about 200 c.c. of hot water, and boiled. The meat is turned frequently, and from time to time, small portions of hot water are added, enough to keep the meat from burning. The pot is kept covered so that the meat has the benefit of the surrounding steam. The temperature of the cooking is considered to be about 100^{0} C., and can be compared with the method of boiling at 100^{0} C.

The roasting of the meat is conducted in a gas oven. The meat is freed from bone, and then rolled and fastened with galvanized iron skewers. A thermometer is so adjusted that the bulb reaches the center of the meat. The roast is then placed on a glass triangle and transferred to an enameled pan. When the temperature of the oven reaches 250^{0} C., the meat is put in, and heated

at this temperature for fifteen minutes. The cooking is then continued at 195 ^{0}C., until the desired inner temperature of the meat is reached. The meat is then removed and placed in a glass jar, where the rise of the inner temperature is noted. In the tables, the inner temperature upon removal of the meat is designated "end", and that due to the rise after removing from the oven, as "final".

Now, as regards the effect of the different methods of cooking upon the chemistry of meat, it is to be regretted that the experiments were not made upon the same cuts of beef, yet we feel justified in making a comparison of the data for the different cuts.

In referring to table No. 11, showing the chemical composition of the cooked meats, it will be noted that in the case of boiling, the percent of moisture in the cooked meat varies inversely as the temperature of cooking. For examples, in the following boiled meats: samples, laboratory Nos. 1801 and 1807, where the temperature was first cold and then raised to 85 ^{0}C.; samples, laboratory Nos. 1802 and 1803, where the meat was put into water of 100 ^{0}C., and then heated at 85 ^{0}C., and in samples, laboratory Nos. 1824 and 1803, where the temperature was 100^{0}C. throughout, the averages of the moisture determinations are 62.85 per cent, 60.62 percent, and 58.5 percent respectively.

Again, in comparing the average of the boiling experiments made at 100 ^{0}C., with that of the pot-roasting experiments, the per cent of moisture is practically the same, being 58.50 and 58.71 respectively. In the case of the roast meat, the moisture content varies from 42.15 percent to 53.33 percent, giving as an average of eight tests, 46.38 percent. As a result of this variation in moisture, the percentage composition of the constituents in the

meats will be inversely increased, in other words, the percent of total dry matter will be proportionate to the rise in temperature of cooking.

Referring to table No. 13, calculated to the water and fat-free basis, it will be seen that the different methods of cooking have a very slight effect upon the total nitrogen content, but in the case of the soluble nitrogen, the solubility increases with the rise in temperature in the boiling experiments, and likewise with the method using the greatest amount of heat. This difference is more marked in the case of the soluble non-proteid nitrogen. Concerning the percentage of ash, it can be said that the total, the soluble and insoluble forms are highest in the roast meats, and lowest in the boiled meats. This is most pronounced in the soluble ash where, in the average for all the boiling experiments, it is 1.13 percent, in that for the pot-roast experiments, 2.00 percent, and in that for the oven-roasting it is 3.07 percent. The organic extractives show that the same general effect is produced upon them as in the case of the ash, the difference being about equally distributed between the two forms, the nitrogenous and non-nitrogenous.

PERCENT of the FORMS of PHOSPHORUS in RAW MEATS.

Table 14. - Calculated to Fresh Basis.

Table 15. - Calculated to Water-free Basis.

Table 16. - Calculated to Water and Fat-free Basis.

Table 14

Per cent of the Forms of Phosphorus in Raw Meat Calculated to Fresh Substance

Laboratory No.	Kind of Meat	Water	Total dry matter (Direct)	Fat	Phosphorus: Soluble: Inorganic	Phosphorus: Soluble: Organic	Phosphorus: Soluble: Total	Phosphorus: Insoluble: Direct	Phosphorus: Insoluble: Indirect	Phosphorus: Total
		%	%	%	%	%	%	%	%	%
1788	Beef, round, raw	73.42	27.40	3.15	.125	.043	.168	.054	.052	.220
1789	do	74.53	26.10	3.59	.102	.044	.146	.051	.064	.210
1823	do	75.61	24.41	2.14	.090	.097	.187	.073	.035	.222
1828	do	75.69	24.95	2.52	.102	.048	.150	.060	.060	.210
1849	do	74.22	26.29	2.46	.148	.101	.249	.079	.062	.311
1850	do	74.89	25.26	2.24	.153	.104	.257	.091	.088	.345
	Average (6)	74.73	25.74	2.68	.120	.073	.193	.068	.060	.253
1853	Veal, shank, raw	75.08	25.44	3.03	.088	.035	.123	.070	.054	.177
1854	do chuck do	72.93	27.98	6.33	.087	.036	.123	.070	.070	.193
1855	do ribs do	68.38	31.91	12.09	.094	.033	.127	.068	.109	.236
1856	do ribs & shoulder do	71.50	29.29	8.57	.102	.031	.133	.123	.136	.269
1857	do breast do	63.34	36.65	16.66	.075	.037	.112	.072	.056	.168
1858	do loin do	68.08	31.40	10.95	.092	.041	.133	.075	.053	.186
1859	do flank do	64.18	36.38	16.13	.094	.018	.112	.063	--	.175
1860	do leg do	73.40	26.04	3.76	.118	.039	.157	.058	.064	.221
1861	do hind shank do	73.36	27.24	5.03	.109	.023	.132	.068	.059	.191
	Average (9)	69.97	30.26	9.17	.095	.032	.128	.074	.074	.202

Table 15

Percent of the Forms of Phosphorus in Raw Meat Calculated to Water-free Basis

Laboratory No.	Kind of Meat	Total dry matter (Direct) %	Fat %	Phosphorus: Soluble: Inorganic %	Soluble: Organic %	Soluble: Total %	Insoluble: Direct %	Insoluble: Indirect %	Total %
1788	Beef, round, raw	100.00	11.50	.456	.157	.613	.197	.190	.803
1789	do	100.00	13.75	.391	.169	.560	.195	.245	.805
1823	do	100.00	8.77	.369	.397	.766	.299	.143	.909
1828	do	100.00	10.10	.409	.192	.601	.240	.240	.841
1849	do	100.00	9.36	.563	.384	.947	.300	.236	1.183
1850	do	100.00	8.87	.606	.411	1.017	.360	.348	1.366
	Average (6)	100.00	10.39	.466	.285	.751	.265	.234	.985
1853	Veal, shank, raw	100.00	11.91	.346	.138	.484	.275	.212	.696
1854	do chuck do	100.00	22.62	.311	.129	.440	.250	.250	.690
1855	do ribs do	100.00	37.89	.295	.103	.398	.213	.341	.740
1856	do ribs & shoulder do	100.00	29.26	.349	.106	.455	.420	.465	.920
1857	do breast do	100.00	45.45	.205	.101	.306	.196	.152	.458
1858	do loin do	100.00	34.87	.293	.131	.424	.239	.168	.592
1859	do flank do	100.00	44.34	.258	.049	.307	.173	--	.481
1860	do leg do	100.00	14.44	.453	.150	.603	.223	.246	.849
1861	do hind shank do	100.00	18.47	.400	.084	.484	.250	.217	.701
	Average (9)	100.00	28.81	.323	.110	.433	.249	.256	.681

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Table 16

Per cent of the Forms of Phosphorus in Raw Meat Calculated to Water- and Fat-free Basis

Laboratory No.	Kind of Meat	Total dry matter (Direct)	Phosphorus: Soluble: Inorganic	Phosphorus: Soluble: Organic	Phosphorus: Soluble: Total	Phosphorus: Insoluble: Direct	Phosphorus: Insoluble: Indirect	Phosphorus: Total
1788	Beef, round, raw	100.00	.516	.177	.693	.223	.214	.907
1789	do	100.00	.453	.196	.649	.227	.284	.933
1823	do	100.00	.404	.436	.840	.328	.157	.997
1828	do	100.00	455	.214	.669	.368	.267	.936
1849	do	100.00	.621	.424	1.045	.332	.260	1.305
1850	do	100.00	.665	451	1.116	.395	.382	1.499
	Average (6)	100.00	.519	.316	.835	.296	.261	1.096
1853	Veal, shank, raw	100.00	.393	.156	.549	.312	.241	.790
1854	do chuck do	100.00	.400	.167	.568	.323	.324	.892
1855	do ribs do	100.00	474	.166	.640	.343	.550	1.191
1856	do ribs & shoulder do	100.00	492	.150	.642	.594	.656	1.298
1857	do breast do	100.00	.375	.185	.560	.360	.280	.840
1858	do loin do	100.00	.450	.200	.650	.367	.259	.909
1859	do flank do	100.00	.464	.089	.553	.311	--	.864
1860	do leg do	100.00	.530	.175	.705	.260	.287	.992
1861	do hind shank do	100.00	.491	.103	.594	.306	.266	.860
	Average (9)	100.00	.452	.155	.607	.353	.358	.960

PERCENT of the FORMS of PHOSPHORUS in RAW MEAT.

In comparing the average of the six analyses of beef round (Table 14) with that of the nine tests of veal, the percents of phosphorus are respectively 0.253 and 0.202 for the total; 0.193 and 0.128 for the total soluble; 0.120 and 0.095 for the inorganic, and 0.073 and 0.032 for the organic forms. From this, it can be seen that the percentage phosphorus content of beef round is higher than that of veal. This increase is most marked in the case of the soluble organic phosphorus where there is a gain of 121 per cent. The insoluble phosphorus decreases in a corresponding manner, being for the beef round 0.060 percent, and for the veal 0.074 percent. This difference cannot be accounted for in considering the moisture or fat content. For in referring to the data where the results are calculated to the water-free basis (Table 15), these instances are more marked than in the former case, the soluble organic phosphorus being 0.285 percent for the beef, and 0.110 percent for the veal, showing an increase in the beef round of 150 percent, whereas it was 121 percent; and the total soluble phosphorus being 0.835 percent for the beef, and 0.607 percent for the veal, showing an increase of 73 percent where it was 50 percent.

At first sight, it would appear, perhaps, that this difference was still due to the fat content, since in Table No. 15, calculated to the water-free basis, the average for the fat in the six tests on beef round is 10.39 percent, with a maximum of 13.75 percent and a minimum of 8.77 percent, while the average for the nine experiments upon veal is 28.81 percent, varying from 11.95 percent in the shank cut, to 45.45 percent in the breast cut.

However, from the data calculated to the water and fat-free basis (Table 16), it can be seen that this difference in the fat content of the beef and veal does not apparently account for the increase of the phosphorus. Yet, by closer inspection, the difference in the averages will be found to have been diminished. Where the total soluble phosphorus had an increase of 50 percent, when calculated to the fresh basis, and one of 73 percent when calculated to the water-free basis, it now has an increase of 37.6 percent; and where the soluble organic phosphorus, calculated to the fresh substance, had an increase of 121 percent, and when calculated to the water-free basis, of 150 percent, it now has one of 104 percent.

Likewise, in considering the cut of veal leg, which corresponds nearest to that of the beef round, a similar comparison of the data can be made to the beef, and even then the percent of soluble organic phosphorus is 0.316 for the beef and 0.175 for the veal leg, showing an increase for the former of 80 percent. The percent of total soluble phosphorus is 0.835 for the beef, and 0.607 for the leg cut, again showing an increase which is 19 per cent. From this, it seems quite apparent that the age of the animal influences the phosphorus content of flesh, the percent of phosphorus varying directly with the increase in age. This statement, however, is subject to the influences which the kind of feed has upon the composition of meat. In this case, it is supposed that the animals from which the beef was gotten were fed upon corn and hay, while the veal was fed upon milk. This phase of the question has, as yet, not been taken up, and until then we feel justified in drawing the above conclusion.

Again, in referring to the data, calculated to the fresh

basis (Table 14), it can be seen that the different cuts of veal contain varying percents of phosphorus, the maximum being, in the case of the shoulder cut, 0.269 percent, and the minimum, in the case of the breast, 0.168 percent. For the beef round, the maximum and minimum percents were 0.345 and 0.210, respectively. These differences in the cuts of veal are just as pronounced when the results are calculated to the water-free basis (Table 15), the minimum percent being 0.920 for the shoulder, and 0.458 for the breast.

It will also be noted in this table (15) that the percent of fat has apparently little influence upon the phosphorus content. The shank cut, for example, has 11.91 percent fat, and 0.696 percent phosphorus, the shoulder 29.26 percent fat and 0.920 percent phosphorus, and the breast 45.45 percent fat and 0.458 percent phosphorus. In the first and second cases, the percentage of phosphorus varies directly with the fat content, while in the first and third instances, the variation is indirect.

Considering the data, where the results are calculated to the water and fat-free basis (Table 16), the maximum percent of phosphorus for the shoulder cut of veal is 1.298, and the minimum percent for the shank is 0.790, showing that the amount of fat does influence the phosphorus content somewhat. The breast cut, which contained the minimum amount when calculated to the fresh and water-free basis, now contains 0.840 percent, or 6.3 percent more than the shank. It is also of interest to note that the fore quarter of the veal, which consists of the first five cuts - shank, chuck, ribs, shoulder and breast - has an increase of 10 percent of the total, 13 percent of the organic, and 32 percent of the insoluble phosphorus over these same forms in the hind quarter. On

the other hand, the fore quarter contains 10 percent less of inorganic, and 6 percent less of the total soluble phosphorus than the hind quarter.

PERCENT of the FORMS of PHOSPHORUS in COOKED MEAT.

Table 17. - Calculated to Fresh Basis.

Table 18. - Calculated to Water-free Basis.

Table 19. - Calculated to Water and Fat-free Basis.

Table 17 Per cent of the Forms of Phosphorus in Cooked Meat
Calculated to Fresh Substance

Laboratory No.	Kind of Meat	Cooking Experiment No.	Method of Cooking: Kind	Temperature: Beginning °C	Temperature: During °C	Temperature, Inner: End °C	Temperature, Inner: Final °C	Time hrs. min.	Water %	Total dry matter (Direct) %	Fat %	Phosphorus, Soluble: Inorganic %	Phosphorus, Soluble: Organic %	Phosphorus, Soluble: Total %	Phosphorus, Insoluble: Direct %	Phosphorus, Insoluble: Indirect %	Phosphorus: Total %
1801	Beef, round	158	Boiling	Cold	85	--	--	3 30	61.26	39.69	3.54	--	--	.075	--	.087	.162
1807	do	161	do	do	85	--	--	6 00	64.44	36.35	2.97	--	--	.067	--	.076	.143
	Average (2)								62.85	38.02	3.26	--	--	.071	--	.082	.153
1808	Beef, round	162	Boiling	100	85	--	--	6 00	61.70	39.00	3.65	--	--	.068	--	.094	.162
1802	do	159	do	100	85	--	--	3 00	59.54	41.44	3.92	--	--	.073	--	.094	.167
	Average (2)								60.62	40.22	3.79	--	--	.071	--	.094	.165
1824	Beef, round	164	Boiling	100	100	--	--	3 00	55.96	44.60	8.47	.085	.041	.126	--	.087	.213
1809	do	163	do	100	100	--	--	5 00	60.61	40.12	3.53	--	--	.081	--	.080	.161
1803	do	160	do	100	100	--	--	2 30	58.94	41.62	3.60	--	--	.081	--	.086	.167
	Average (3)								58.50	42.11	5.20	--	--	.096	--	.084	.180
	Average (7)								60.35	40.40	4.24	--	--	.082	--	.086	.168
1825	Beef, round	165	Pot-roast	--	--	--	--	3 00	56.92	44.35	5.58	.122	.059	.181	--	.083	.264
1829	do	166	do	--	--	--	--	3 00	57.57	42.85	4.20	.112	.049	.161	.100	.066	.227
1830	do	167	do	--	--	--	--	3 00	61.65	38.80	4.79	.104	.018	.122	.082	.103	.225
	Average (3)								58.71	42.00	4.86	.113	.042	.155	.091	.084	.239
1831	Beef, rib, 4th	168	Roast	250	195	43	52.0	1 00	44.78	55.08	36.84	.095	.023	.118	.047	.030	.148
1833	do 3d & 4th	169	do	250	195	43	57.0	1 40	47.33	52.33	32.11	.089	.035	.124	.044	.034	.158
1837	do do	170	do	250	195	43	56.5	1 30	53.33	47.07	25.21	.089	.039	.128	.073	.059	.187
1838	do do	171	do	250	195	55	62.5	1 35	49.73	50.67	27.79	.104	.044	.148	.055	.042	.190
1840	do do	172	do	250	195	55	61.5	2 15	42.35	58.07	37.16	.081	.038	.119	.056	.048	.167
1848	do do	176	do	250	195	55	62.0	2 15	Lost	--	Lost	.102	.047	.149	--	.049	.198
1842	do do	173	do	250	195	55	61.5	1 50	45.73	54.64	35.19	.090	.032	.122	.061	.037	.159
1844	do do	174	do	250	195	70	74.0	3 00	42.15	58.25	34.42	.097	.042	.139	.067	.054	.193
1846	do do	175	do	250	195	70	73.0	2 45	45.63	55.10	27.60	.120	.038	.158	.068	.056	.214
	Average (9)								46.38	53.90	32.04	.096	.038	.134	.059	.045	.179

Table 10 Per cent of the Forms of Phosphorus in Cooked Meat
Calculated to Water-free Basis

Laboratory No.	Kind of Meat	Cooking Experiment No.	Method of Cooking: Kind	Temperature: Beginning °C	Temperature: During °C	Temperature: Inner: End °C	Temperature: Inner: Final °C	Time: hrs	Time: min	Total dry matter (Direct) %	Fat %	Phosphorus: Soluble: Inorganic %	Phosphorus: Soluble: Organic %	Phosphorus: Soluble: Total %	Phosphorus: Insoluble: Direct %	Phosphorus: Insoluble: Indirect %	Phosphorus: Total %
1801	Beef, round	158	Boiling	Cold	85	..	..	3	30	100.00	8.92	..	..	.189	..	.219	.408
1807	do	161	do	do	85	..	..	6	00	100.00	8.17	..	..	.184	..	.209	.393
	Average (2)									100.00	8.55	..	..	.187	..	.214	.401
1808	Beef, round	162	Boiling	100	85	..	..	6	00	100.00	9.36	..	..	.174	..	.241	.415
1802	do	159	do	100	85	..	..	3	00	100.00	9.46	..	..	.176	..	.227	.403
	Average (2)									100.00	9.41	..	..	.175	..	.234	.409
1824	Beef, round	164	Boiling	100	100	..	..	3	00	100.00	18.99	.191	.092	.283	..	.195	.478
1809	do	163	do	100	100	..	..	5	00	100.00	8.80	..	..	.202	..	.199	.401
1803	do	160	do	100	100	..	..	2	30	100.00	8.65	..	..	.195	..	.207	.401
	Average (3)									100.00	12.15	..	..	.227	..	.200	.427
	Average (7)									100.00	10.34	..	..	.200	..	.214	.414
1825	Beef, round	165	Pot roast	..	..	..	..	3	00	100.00	12.58	.275	.133	.408	..	.187	.595
1829	do	166	do	..	..	..	..	3	00	100.00	9.80	.261	.114	.375	.233	.154	.529
1830	do	167	do	..	..	..	..	3	00	100.00	12.35	.268	.046	.314	.211	.265	.580
	Average (3)									100.00	11.58	.268	.098	.366	.222	.202	.568
1831	Beef, rib, 4th	168	Roast	250	195	43	52.0	1	00	100.00	66.88	.172	.042	.214	.085	.055	.269
1833	do 3d+4th	169	do	250	195	43	57.0	1	40	100.00	61.26	.170	.067	.237	.084	.064	.301
1837	do do	170	do	250	195	43	56.5	1	30	100.00	53.54	.189	.083	.272	.155	.126	.398
1838	do do	171	do	250	195	55	62.5	1	35	100.00	54.85	.205	.087	.292	.109	.083	.375
1840	do do	172	do	250	195	55	61.5	2	15	100.00	63.99	.139	.066	.205	.096	.083	.288
1842	do do	173	do	250	195	55	61.5	1	50	100.00	64.43	.165	.058	.223	.112	.068	.291
1844	do do	174	do	250	195	70	74.0	3	00	100.00	59.09	.167	.072	.239	.115	.092	.331
1846	do do	175	do	250	195	70	73.0	2	45	100.00	50.09	.218	.069	.287	.123	.101	.388
	Average (8)									100.00	59.27	.178	.068	.246	.109	.084	.330

Table 19 Per cent of the Forms of Phosphorus in Cooked Meat Calculated to Water- and Fat-free Basis

Laboratory No.	Kind of Meat	Cooking Experiment No.	Method of Cooking: Kind	Temperature: Beginning °C	Temperature: During °C	Temperature: Inner: End °C	Temperature: Inner: Final °C	Time hrs. min.	Total dry matter (Direct) %	Phosphorus: Soluble: Inorganic %	Phosphorus: Soluble: Organic %	Phosphorus: Soluble: Total %	Phosphorus: Insoluble: Direct %	Phosphorus: Insoluble: Indirect %	Phosphorus: Total %
1801	Beef, round	158	Boiling	Cold	85	--	--	3 30	100.00	--	--	.207	--	.241	.448
1807	do	161	do	do	85	--	--	6 00	100.00	--	--	.201	--	.228	.428
	Average (2)								100.00	--	--	.204	--	.234	.438
1808	Beef, round	162	Boiling	100	85	--	--	6 00	100.00	--	--	.192	--	.266	.458
1802	do	159	do	100	85	--	--	3 00	100.00	--	--	.195	--	.251	.446
	Average (2)								100.00	--	--	.194	--	.258	.452
1824	Beef, round	164	Boiling	100	100	--	--	3 00	100.00	.235	.114	.349	--	.241	.590
1809	do	163	do	100	100	--	--	5 00	100.00	--	--	.221	--	.219	.440
1803	do	160	do	100	100	--	--	2 30	100.00	--	--	.213	--	.226	.439
	Average (3)								100.00	--	--	.261	--	.229	.490
	Average (7)								100.00	--	--	.225	--	.239	.464
1825	Beef, round	165	Pot-roast	--	--	--	--	3 00	100.00	.315	.152	.467	--	.214	.681
1829	do	166	do	--	--	--	--	3 00	100.00	.290	.127	.417	.259	.171	.588
1830	do	167	do	--	--	--	--	3 00	100.00	.306	.053	.359	.241	.303	.662
	Average (3)								100.00	.303	.111	.414	.250	.230	.644
1831	Beef, rib, 4th	168	Roast	250	195	43	52.0	1 00	100.00	.521	.126	.647	.258	.164	.811
1833	do 3d & 4th	169	do	250	195	43	57.0	1 40	100.00	.440	.173	.613	.218	.168	.781
1837	do do	170	do	250	195	43	56.5	1 30	100.00	.407	.178	.586	.334	.270	.855
1838	do do	171	do	250	195	55	62.5	1 35	100.00	.455	.192	.647	.240	.183	.830
1840	do do	172	do	250	195	55	61.5	2 15	100.00	.387	.182	.569	.268	.230	.799
1842	do do	173	do	250	195	55	61.5	1 50	100.00	.463	.164	.627	.314	.190	.817
1844	do do	174	do	250	195	70	74.0	3 00	100.00	.407	.176	.583	.281	.227	.810
1846	do do	175	do	250	195	70	73.0	2 45	100.00	.436	.138	.574	.247	.204	.778
	Average (8)								100.00	.440	.166	.606	.270	.204	.810

From the data calculated to the fresh basis (Table 17) and that calculated to the water-free basis (Table 18), no definite conclusions can be drawn as regards the influence of the different methods of boiling meat, because of the slight variations in the determinations. The indications are, however, that the higher the temperature of the water the greater is the percent of total phosphorus in the meat. There seems to be no constant relation between any of these methods of boiling as regards the total soluble phosphorus.

In comparing the average of all the boiled meats (Table 17) with those from the pot-roast and oven-roast meats, it will be seen that there is little difference in the total phosphorus between the meats cooked by boiling and oven-roasting, the percents being 0.168 and 0.179, respectively, but in the case of the pot-roast meat, the phosphorus content is higher, being 0.239 percent. The average percent of total soluble phosphorus in boiled meats is 0.082, varying from 0.067 to 0.126; that in the pot-roast meat is 0.155, having a minimum of 0.122 and a maximum of 0.181; and that in the oven-roast is 0.134, varying from 0.118 to 0.158.

From this, we see that, of the total soluble phosphorus in cooked meats, the pot-roast has the greatest percentage, the oven-roast next, and the boiled the least. The same relation holds when the results are calculated to the water-free basis (Table 18). This increase in the percent of total phosphorus is apparently due to

the inorganic form which constitutes 0.113 percent of the total in the pot-roast, and 0.096 percent in the oven-roast meat.

In considering the data, calculated to the water-free and fat-free content (Table 19), we have the variations due to the water and fat eliminated, and the results are more strictly comparable. Here, the methods of boiling meat show a difference, for in taking the average of the total phosphorus content, it will be found that they vary directly as the rise in temperature. In the case where the water was first cold and then heated to 85^{0}C., the percent of phosphorus is 0.438; where the water was first 100^{0}C., then 85^{0}, the percent is 0.452, and where the temperature was highest, 100^{0}C., the phosphorus content is 0.490 percent, giving an average for all the tests of 0.464 percent. As to the total soluble phosphorus, it is highest in the case where the meat was boiled at 100^{0}C., being 0.361 percent. In the other two instances, there is practically no difference, the percents being 0.204 and 0.194, respectively, for the meat cooked in the cold, then at 85^{0}C., and that cooked at 100^{0}, then 85^{0}C.

As regards a comparison of the three general methods of cooking, the total phosphorus content is 0.464 percent for the boiled meat, with a minimum percent of 0.428, and a maximum of 0.590; 0.644 percent for the pot-roast meat, varying from 0.588 percent to 0.681 percent, and for the oven-roast meat, it is 0.810 percent, the maximum and minimum percents being 0.855 and 0.778, respectively. This shows that the oven-roast meat contains more phosphorus than either the boiled or pot-roast, and of these two, the pot-roast contains the most. The same statements can be made regarding the total soluble phosphorus, the boiled meat containing

0.225 percent, the pot-roast 0.414 percent, and the oven-roast 0.606 percent. As regards the soluble inorganic phosphorus, the pot-roast meat contains as an average of the three tests, 0.303 percent, varying from 0.290 percent to 0.315 percent. The oven-roast meat has as the maximum percent of inorganic phosphorus, 0.521 and as the minimum, 0.387, with an average of 0.440 percent for the eight experiments. From this, it is evident that there is more inorganic phosphorus in the case of the pot-roast meat. The organic phosphorus content is somewhat higher in the oven-roast than in the pot-roast meat, being on an average for each case, 0.166 percent and 0.111 percent, respectively.

Now, in considering the data from tables Nos. 16 and 17, where we have the phosphorus content of both the raw and cooked meats calculated to the water and fat-free basis, an idea can be obtained as to the effect of the methods of cooking upon meat. A direct comparison can only be made where the same cut of meat has been used in each case. The total phosphorus in the raw beef round is 1.096 percent, in the boiled meat 0.464 percent, and in the pot-roast meat 0.644 percent, representing a loss of phosphorus due to the method of cooking, in the boiled meat of 57.66 percent, and in the pot-roast meat of 41.25 percent. The total soluble phosphorus in the raw, the boiled and pot-roast meat is 0.835, 0.226 and 0.414 percent, respectively, showing a decrease of 73.1 percent in the boiled meat, and one of 50.4 percent in the pot-roast meat. This indicates that boiled meats lose more total and soluble phosphorus than pot-roast meats.

FORMS of PHOSPHORUS in RAW MEATS EXPRESSED in
PERCENTAGE of TOTAL PHOSPHORUS.

SOLUBLE FORMS of PHOSPHORUS in RAW MEATS EXPRESSED in
PERCENTAGE of TOTAL SOLUBLE PHOSPHORUS.

Table 20. - Calculated on the Basis of the Raw Meat.

Table 21. - Calculated on the Basis of the Cooked Meat.

Table 20

Forms of Phosphorus Expressed in Percentage of Total Phosphorus

Soluble Forms of Phosphorus Expressed in Percentage of Total Soluble Phosphorus

Laboratory No.	Kind of Meat	Total Phosphorus %	Soluble Phosphorus %	Total Phosphorus: Soluble			Total Phosphorus: Insoluble			Soluble Phosphorus		
				Inorganic %	Organic %	Total %	Direct %	Indirect %	Total %	Inorganic %	Organic %	Total %
1788	Beef, round, raw	.220	.168	56.82	19.54	76.36	24.55	23.64	100.00	74.41	25.59	100.00
1789	do	.210	.146	48.57	20.95	69.52	24.29	30.48	100.00	69.86	30.14	100.00
1823	do	.222	.187	40.54	38.29	78.83	32.88	21.17	100.00	51.43	48.57	100.00
1828	do	.210	.150	48.57	22.86	71.43	28.57	28.57	100.00	68.00	32.00	100.00
1849	do	.311	.249	47.59	32.48	80.07	25.40	19.93	100.00	59.44	40.56	100.00
1850	do	.345	.257	44.35	30.14	74.49	26.38	25.51	100.00	59.54	40.46	100.00
	Average (6)	.253	.193	47.74	27.38	75.12	27.02	24.88	100.00	63.78	36.22	100.00
1853	Veal shank raw	.177	.123	49.75	19.75	69.49	39.49	30.51	100.00	71.54	28.46	100.00
1854	do chuck do	.193	.123	45.12	18.63	63.75	36.25	36.25	100.00	70.73	29.27	100.00
1855	do ribs do	.236	.127	39.80	14.02	53.82	28.80	46.18	100.00	74.02	25.98	100.00
1856	do ribs & shoulder do	.269	.133	37.92	11.54	49.46	45.69	50.54	100.00	76.69	23.31	100.00
1857	do breast do	.168	.112	44.65	22.02	66.67	42.86	33.33	100.00	66.96	33.04	100.00
1858	do loin do	.186	.133	49.45	21.98	71.43	40.33	28.57	100.00	69.17	30.83	100.00
1859	do flank do	.175	.112	53.70	10.30	64.00	36.00	- -	100.00	83.93	16.07	100.00
1860	do leg do	.221	.157	53.43	17.64	71.07	26.21	28.93	100.00	75.16	24.84	100.00
1861	do hind shank do	.191	.132	57.07	12.04	69.11	35.58	30.93	100.00	82.58	17.42	100.00
	Average (9)	.202	.128	47.88	16.43	64.31	36.80	35.69	100.0	74.53	25.47	100.00

Table 21 Forms of Phosphorus Expressed in Percentage of Total Phosphorus
Soluble Forms of Phosphorus Expressed in Percentage of Total Soluble Phosphorus

Laboratory No.	Kind of Meat	Cooking Experiment No.	Method of Cooking: Kind	Temperature: Beginning °C	Temperature: During °C	Time hr. min	Total Phosphorus %	Soluble Phosphorus %	Total Phosphorus: Soluble: Inorganic %	Total Phosphorus: Soluble: Organic %	Total Phosphorus: Soluble: Total %	Total Phosphorus: Insoluble: Direct %	Total Phosphorus: Insoluble: Indirect %	Total Phosphorus: Total %	Soluble Phosphorus: Inorganic %	Soluble Phosphorus: Organic %	Soluble Phosphorus: Total %
1801	Beef, round	158	Boiling	Cold	85	3 30	.162	.075	--	--	46.29	--	53.71	100.00	--	--	100.00
1807	do	161	do	do	85	6 00	.143	.067	--	--	46.85	--	53.15	100.00	--	--	100.00
	Average (2)						.153	.071	--	--	46.57	--	53.43	100.00	--	--	100.00
1808	Beef, round	162	Boiling	100	85	6 00	.162	.068	--	--	41.98	--	58.02	100.00	--	--	100.00
1802	do	159	do	100	85	3 00	.167	.073	--	--	43.71	--	56.29	100.00	--	--	100.00
	Average (2)						.165	.071	--	--	42.85	--	57.15	100.00	--	--	100.00
1824	Beef, round	164	Boiling	100	100	3 00	.213	.126	39.91	19.24	59.15	--	40.85	100.00	67.46	32.54	100.00
1809	do	163	do	100	100	5 00	.161	.081	--	--	50.31	--	49.69	100.00	--	--	100.00
1803	do	160	do	100	100	2 30	.167	.081	--	--	48.50	--	51.50	100.00	--	--	100.00
	Average (3)						.180	.096	--	--	52.65	--	47.35	100.00	--	--	100.00
	Average (7)						.168	.082	--	--	48.11	--	51.89	100.00	--	--	100.00
1825	Beef, round	165	Pot-roast	--	--	3 00	.264	.181	46.21	22.35	68.56	--	31.44	100.00	67.40	32.60	100.00
1829	do	166	do	--	--	3 00	.227	.161	49.34	21.59	70.93	44.05	29.07	100.00	69.57	30.43	100.00
1830	do	167	do	--	--	3 00	.225	.122	46.21	8.00	54.22	36.44	45.78	100.00	85.25	14.75	100.00
	Average (3)						.239	.155	47.26	17.31	64.57	40.25	35.42	100.00	74.07	25.93	100.00
1831	Beef, rib 4th	168	Roast	250	195	1 00	.148	.118	64.19	15.54	79.73	31.76	20.27	100.00	80.51	19.49	100.00
1833	do 3d & 4th	169	do	250	195	1 40	.158	.124	56.33	22.15	78.48	27.85	21.52	100.00	71.77	28.23	100.00
1837	do do	170	do	250	195	1 30	.187	.128	47.59	20.86	68.45	39.04	31.55	100.00	69.53	30.47	100.00
1838	do do	171	do	250	195	1 35	.190	.148	54.74	23.15	77.89	28.85	22.11	100.00	70.27	29.73	100.00
1840	do do	172	do	250	195	2 15	.167	.119	48.50	22.76	71.26	33.53	28.74	100.00	68.07	31.93	100.00
1848	do do	176	do	250	195	2 15	.198	.149	51.52	23.73	75.25	--	24.75	100.00	68.46	31.54	100.00
1842	do do	173	do	250	195	1 50	.159	.122	56.60	20.13	76.73	38.36	23.27	100.00	73.77	26.23	100.00
1844	do do	174	do	250	195	3 00	.193	.139	50.26	21.76	72.02	34.72	27.98	100.00	69.78	30.22	100.00
1846	do do	175	do	250	195	2 45	.214	.158	56.07	17.76	73.83	31.78	26.17	100.00	75.95	24.05	100.00
	(9)						.179	.134	53.98	20.87	74.85	33.24	25.15	100.00	72.01	27.99	100.00

Of the average of the total phosphorus of beef round, 75.12 percent is soluble in cold water. Of this, the minimum percent is 69.52, and the maximum, 80.07. In the case of the veal, 64.31 percent of the total phosphorus is soluble, the minimum amount being 49.46 percent, and the maximum, 71.43 percent. This fact agrees with Hart and Andrews, in their work upon germinated seeds, where they found that upon development, the percent of soluble phosphorus increased.

Of the phosphorus in beef round. 47.74 percent was found to be soluble inorganic, and 27.38 percent organic, while in the veal, 47.88 percent was soluble inorganic, and 16.43 percent organic. From this, it will be seen that the increase in the soluble phosphorus lies apparently within the organic form. By referring to table 18, where the results for the composition of meats are calculated to the water and fat-free basis, it will be seen that there is also an increase of 30 percent in the soluble proteid, one of 22.5 percent in the nitrogenous extractives, and one of 20 percent in the soluble ash, showing that the increase is general and chiefly in the organic form. This statement differs from that of Iwanoff, Zaleski, and Schulze and Castoro, who, in working with plants and seeds, found that the percent of inorganic phosphorus increased upon germination, and that the organic form decreased.

Again, in referring to the previous table, and comparing

the cut of veal leg with the average of the beef round, we will find the same thing again; the soluble inorganic phosphorus of the veal leg is 10.6 percent greater than that of the beef round, while the organic phosphorus is 55.2 percent less.

If we compare these same forms of phosphorus in the case of the fore and hind quarter of the veal, we will find the same state of affairs. In the fore quarter there is a decrease of 23 percent of the soluble inorganic, and an increase of 11.6 percent of organic phosphorus over those in the hind quarter. The average composition of the hind quarter compares very favorably with that of the cut of veal leg.

Now, taking up the percentage composition of the soluble phosphorus, we find that the organic phosphorus of the beef round constitutes about one-third of the total, while that of the veal constitutes about one-fourth. The ratio of the organic phosphorus to the inorganic is, in the case of the beef round, about 3/5, and of the veal, 1/3. This last figure agrees with Macleod, in his work upon rested and fatigued dogs. From the averages of each meat, the beef round contains 10.75 percent more organic phosphorus than the veal, and loses a corresponding percent of the inorganic.

Generally speaking, then, it may be said that age increases the soluble phosphorus content and decreases the insoluble, that it increases the soluble organic phosphorus but does not effect the soluble inorganic, and that of the soluble phosphorus, the percent of the organic is increased, while that of the inorganic is decreased.

In considering the composition of the forms of the total phosphorus, it will be seen in the case of boiled meats, that apparently the methods of cooking have a different effect than that which we would at first expect. The percent of the total phosphorus which is soluble in water does not necessarily decrease with the rise in temperature, for if we note the average of the two tests made upon the meat by putting it in cold water and then raising the temperature to 85^{0}C., the percentage of the soluble phosphorus is 46.57, while that from cooking the meat at 100^{0}C. is 52.65, its maximum and minimum percents being 59.15 and 48.50, respectively.

This same condition exists when we compare the proportions of the total phosphorus which are soluble in the case of meat cooked at 100^{0}C. with that cooked first at 100^{0}C., and then at 85^{0}C. In the latter case, the percents varied from 41.98 to 43.71, with an average for all the tests of 42.87 percent. The explanation for this variation, in the case of the meats cooked at 100^{0}C., is doubtless due to the fact that when the meat is plunged into the boiling water, the albumen is immediately coagulated upon the outer surface, and forms a temporary coating through which the hot water cannot extract the soluble phosphorus. By continued heating at this high temperature, the albumen becomes coagulated within and mechanically holds the phosphorus.

In averaging the entire series of boiling experiments, and comparing this with those from the other methods of cooking, we find that of the total phosphorus, the percent soluble in the

case of boiled meats is 48.11, the maximum being 59.15, and the minimum, 41.98. Meats cooked by pot-roasting have an average percent of soluble phosphorus of 64.57, varying from 54.22 to 70.93, and in the case of oven-roasted meat, the maximum percent is 79.73, and the minimum, 68.45, with an average of 74.85. In other words, of the total amount of phosphorus in cooked meats, the soluble proportion is least in the boiled meat, highest in the oven-roasted meat, and intermediate in the case of the pot-roasted.

Of the soluble portion of the total phosphorus, the increase in the cases of roasted meats is proportionally divided between the organic and inorganic forms. In the oven-roasted meat, the average of the inorganic phosphorus for the nine tests is 53.98 percent, with a maximum of 64.19 percent, and a minimum of 47.59 percent. For the pot-roast meat, the variations in the inorganic phosphorus are from 46.21 percent to 49.34 percent, with an average for the three experiments of 47.25 percent, making it 14 percent lower than that in the oven-roast meat.

Eliminating the low determination of the organic phosphorus for sample No. 1830, the averages for the pot and oven-roast meats are practically the same, being for the former, 22.47 percent, and for the latter, 20.87 percent. On the other hand, if we take the average of all the tests for the pot-roast, it will be about 20 percent lower than that for the oven roast meats.

In comparing the percentage composition of the phosphorus of the cooked beef round with that of the raw meat of the same cut (Table 20), it will be seen from the averages of the seven boiled meats that the percent of soluble phosphorus is 48.11, and in the case of the raw meat, 75.12. This shows a loss of 56 percent.

Considering the average of the pot-roasts, the soluble phosphorus is 64.57 percent, representing a loss of about 16 percent, showing again that boiled meat loses more soluble phosphorus than that cooked by pot-roasting. The inorganic phosphorus in the pot-roasted beef round constitutes 47.25 percent of the total phosphorus, while that of the raw meat forms 47.74 percent, showing that the greatest loss is not due to this form of phosphorus.

Now, in studying the percentage composition of the soluble phosphorus, it will be noted that in the boiled meat, one-third of it, 32.54 percent, is organic, and the other two-thirds, inorganic; in pot-roast meats, if we again eliminate No. 1830, the same percent exists, being 31.52 percent, and on the other hand, if we average all three tests, the percent is 25.93 , or one-fourth. With the oven-roasted meats, 27.99 percent of the soluble phosphorus is organic, or a little more than one-fourth. These percents for the cooked beef round correspond quite closely with that of the raw meat (Table 20), which is 36.22 percent.

FORMS of PHOSPHORUS in RAW MEATS EXPRESSED in
PERCENTAGE of TOTAL ASH.

SOLUBLE FORMS of PHOSPHORUS in RAW MEATS EXPRESSED in
PERCENTAGE OF TOTAL SOLUBLE ASH.

Table 22. - Calculated on the Basis of the Fresh Meat.

Table 23. - Calculated on the Basis of the Cooked Meat.

Table 22

Forms of Phosphorus Expressed in Percentage of Total Ash

Forms of Soluble Phosphorus Expressed in Percentage of Total Soluble Ash

Laboratory No.	Kind of Meat	Total Ash %	Soluble Ash %	Total Ash: Soluble: Inorganic %	Total Ash: Soluble: Organic %	Total Ash: Soluble: Total %	Total Ash: Insoluble: Direct %	Total Ash: Insoluble: Indirect %	Total Ash: Total %	Soluble Ash: Inorganic %	Soluble Ash: Organic %	Soluble Ash: Total %
1788	Beef, round, raw	1.090	.874	11.47	3.94	15.41	4.94	4.77	20.18	14.30	4.92	19.22
1789	do	1.060	.947	9.62	4.15	13.77	4.81	6.04	19.81	10.77	4.65	15.42
1823	do	1.080	1.002	8.33	7.87	16.20	6.76	4.36	20.56	8.98	8.48	17.46
1828	do	1.060	.940	9.62	4.53	14.15	5.66	5.66	19.81	10.85	5.11	15.96
1849	do	1.110	.988	13.46	9.18	22.64	7.18	5.63	28.27	14.98	10.22	25.20
1850	do	1.080	.991	14.17	9.63	23.80	8.43	8.14	31.94	15.44	10.49	25.93
	Average (6)	1.080	.960	11.11	6.55	17.66	6.30	5.77	23.43	12.55	7.32	19.87
1853	Veal shank raw	1.018	.656	8.64	3.44	12.08	6.88	5.30	17.39	13.41	5.34	18.75
1854	do chuck do	.995	.667	8.74	3.62	12.36	7.04	7.04	19.40	13.04	5.40	18.44
1855	do ribs do	.968	.667	9.71	3.41	13.12	7.02	11.26	24.38	14.09	4.95	19.04
1856	do ribs & shoulder do	1.041	.737	9.80	2.98	12.78	11.82	13.06	25.84	13.84	4.21	18.05
1857	do breast do	.897	.655	8.36	4.13	12.49	8.03	6.25	18.67	11.45	5.65	17.10
1858	do loin do	.978	.735	9.41	4.19	13.60	7.67	5.42	19.02	12.52	5.58	18.10
1859	do flank do	.947	.778	9.93	1.90	11.83	6.65	- -	18.48	12.08	2.32	14.40
1860	do leg do	1.094	.887	10.79	3.56	14.35	5.30	5.85	20.20	13.30	4.40	17.70
1861	do hind shank do	1.029	.761	10.59	2.24	12.83	6.61	5.73	18.56	14.32	3.03	17.35
	Average (9)	.996	.727	9.55	3.28	12.83	7.45	7.49	20.22	13.12	4.54	17.66

Table 23 Forms of Phosphorus Expressed in Percentage of Total Ash
Soluble Forms of Phosphorus Expressed in Percentage of Total Soluble Ash

Laboratory No.	Kind of Meat	Cooking Experiment No.	Method of Cooking: Kind	Temperature: Beginning	Temperature: During °C	Time hrs. min	Total Ash %	Soluble Ash %	Total Ash: Soluble: Inorganic %	Total Ash: Soluble: Organic %	Total Ash: Soluble: Total %	Total Ash: Insoluble: Direct %	Total Ash: Insoluble: Indirect %	Total Ash: Total %	Soluble Ash: Inorganic %	Soluble Ash: Organic %	Soluble Ash: Total %
1801	Beef, round	158	Boiling	Cold	85	3 30	.58	.34	..	..	12.93	..	15.00	27.93	..	..	22.06
1807	do	161	do	do	85	6 00	.49	.31	..	..	13.67	..	15.51	29.18	..	..	21.61
	Average (2)						.54	.33	..	..	13.30	..	15.26	28.56	..	..	21.84
1808	Beef, round	162	Boiling	100	85	6 00	.56	.42	..	..	12.14	..	16.79	28.93	..	..	16.19
1802	do	159	do	100	85	3 00	.57	.31	..	..	12.81	..	16.49	29.30	..	..	23.55
	Average (2)						.57	.37	..	..	12.48	..	16.64	29.12	..	..	19.87
1824	Beef, round	164	Boiling	100	100	3 00	.83	.62	10.24	4.94	15.18	..	10.82	26.00	13.71	6.61	20.32
1809	do	163	do	100	100	5 00	.62	.44	..	..	13.07	..	12.90	25.97	..	..	18.41
1803	do	160	do	100	100	2 30	.60	.42	..	..	13.50	..	14.33	27.83	..	..	19.28
	Average (3)						.68	.49	..	..	13.92	..	12.68	26.60	..	..	19.34
	Average (7)						.61	.41	..	..	13.33	..	14.55	27.88	..	..	20.20
1825	Beef, round	165	Pot-roast	..	..	3 00	1.24	1.03	9.84	4.76	14.60	..	6.69	21.29	11.84	5.73	17.57
1829	do	166	do	..	..	3 00	.95	.68	11.79	5.16	16.95	10.53	6.95	23.90	16.47	7.21	23.68
1830	do	167	do	..	..	3 00	.74	.54	14.05	2.44	16.49	11.08	13.92	30.41	19.26	3.33	22.59
	Average (3)						.98	.75	11.89	4.12	16.01	10.80	9.19	25.20	15.86	5.42	21.28
1831	Beef, rib 4th	168	Roast	250	195	1 00	.83	.65	11.45	2.77	14.22	5.66	3.61	17.83	14.62	3.53	18.15
1833	do 3d & 4th	169	do	250	195	1 40	.80	.65	11.13	4.37	15.50	5.50	4.25	19.75	13.69	5.39	19.08
1837	do do	170	do	250	195	1 30	.89	.77	10.00	4.38	14.38	8.20	6.63	21.01	11.56	5.06	16.62
1838	do do	171	do	250	195	1 35	.90	.71	11.55	4.89	16.44	6.12	4.67	21.11	14.65	6.20	20.85
1840	do do	172	do	250	195	2 15	.77	.66	10.52	4.93	15.45	7.27	6.24	21.69	12.27	5.76	18.03
1848	do do	176	do	250	195	2 15	1.03	.83	9.90	4.56	14.46	..	4.76	19.22	12.29	5.66	17.95
1842	do do	173	do	250	195	1 50	.88	.67	10.23	3.63	13.86	6.93	4.20	18.07	13.43	4.78	18.21
1844	do do	174	do	250	195	3 00	1.01	.70	9.60	4.16	13.76	6.63	5.35	19.11	13.86	6.00	19.86
1846	do do	175	do	250	195	2 45	1.06	.44	11.32	3.59	14.91	6.42	5.28	20.19	27.27	8.64	35.91
	Average (9)						.91	.68	10.63	4.15	14.78	6.59	5.00	19.78	14.55	5.67	20.52

In the beef round, the total phosphorus constitutes 23.43 percent of the ash, the minimum and maximum percents being 19.81 and 31.94, respectively. For the veal, 20.22 percent of the ash is phosphorus, the minimum and maximum figures being respectively, 17.39 and 25.84. Of this ash, 17.83 percent, for the beef round, and 12.83 percent for the veal, is soluble phosphorus. In the beef round, this varied from 13.77 percent to 23.80 percent, and in the veal from 11.83 to 14.35, the maximum percent being in the leg cut which corresponds to that of beef round. It is again evident that the younger animal has less soluble phosphorus than the older one.

Similarly, there is 5.77 percent of the phosphorus in the ash of the beef round which is insoluble in water, and 7.49 percent in that of the veal. In the case of the veal, the maximum percent of the ash which is soluble in cold water is 13.06 in the shoulder cut, and the minimum is 5.30 in the shank. This fact, together with the high percent of insoluble phosphorus in the rib cut, 11.26 percent, would indicate that the meat nearest the bony structure is liable to contain more calcium phosphate.

Of the soluble portion of the total phosphorus, in the case of beef round, 11.11 percent of it is made up of the inorganic form, the maximum and minimum percents being 8.33 and 4.17, respectively. If this average were calculated to the potassium salt, KH_2PO_4, which is the most predominant in flesh, it would give 48.88

percent. But after ignition, the ash contains not only the di-phosphate but also some of the mono- and tri-phosphates. The soluble portion of the total phosphorus of the veal contains 9.55 percent of the inorganic form. The total soluble ash contains 19.87 percent phosphorus, in the case of the beef round, and 17.66 percent, in the case of the veal. Of this amount, in the beef round, 37 percent of it is organic phosphorus, and in the veal, 26 percent, while there is a corresponding decrease in the inorganic form of phosphorus.

In taking up the boiled meats, it will be seen that the total phosphorus content of the ash varies directly as the rise in temperature in the cases of meat cooked by putting it in the cold and heating to 85°C., and by putting it in boiling water and then heating it at 85°C., the averages being 28.56 percent, and 29.12 percent, respectively. For the meat cooked at 100°C. throughout, there is a much lower percentage of phosphorus in the ash, 26.60, showing that this method of cooking removes a greater proportion of the total ash than it does of phosphorus.

As regards the percent of soluble phosphorus in the ash of boiled meats, it varies just as its percentage of total phosphorus (Table 21), decreasing with the rise in temperature in cases where the water was first cold then heated to 85°C., and where it was first 100°C. then allowed to drop to 85°C, being 13.30 and 12.48 percent, respectively. Where the meat was cooked at 100°C.,

the amount of soluble phosphorus was higher, being 13.92 percent, and showing the mechanical effect of the coaguable albumen in holding the constituent back.

In considering the three general methods of cooking - boiling, pot-roasting and oven-roasting - the amount of phosphorus in the ash is lowest in the last case, varying from 17.83 percent to 21.96 percent, with an average for the nine tests of 19.78 percent. The average of the pot-roasted experiments shows 25.20 percent of the ash to be phosphorus, the maximum and minimum percents being 30.41 and 21.29, respectively. The ash of the boiled meats contains the highest percent of phosphorus, being 27.88 percent for the average of seven experiments. The maximum amount was 29.30 percent, and the minimum, 25.99 percent.

Of the total phosphorus, the insoluble portion varies in the same manner as the total phosphorus, having as an average, 5.00 percent for the oven-roasted meat, 9.19 percent for the pot-roasted, and 14.55 percent for the boiled meat. The percent of soluble phosphorus does not follow the inverse ratio, as we would expect, considering the variations in the total and insoluble phosphorus. It is highest in the case of the pot-roast, being 16.01 percent, and lowest in the case of the boil, being 13.33 percent. The oven-roast shows 14.78 percent of the ash to be soluble phosphorus, this being less than the pot-roast and more than the boiled.

Little can be said as regards the differences in the percents of organic and inorganic phosphorus in the roasting experiments. The averages for the organic phosphorus are, for the pot-roast, 14.12 percent, and for the oven-roast, 14.15 percent. The individual differences are also about constant. The average for

the inorganic phosphorus in the case of the pot-roast is 11.89 percent, and in that of the oven-roast, 10.63 percent.

In comparing the analyses of the raw and cooked beef round (Tables 22 and 23), we see that in boiled meat ~~the percent of the total phosphorus in~~ the ash increases from 23.43 percent to 27.88 percent, for the total phosphorus, and from 5.77 percent to 14.55 percent, for the insoluble form, while it decreases from 17.83 percent to 13.33 percent, for the total soluble phosphorus. In pot-roasting, the variations are slight except in the case of the insoluble phosphorus where the raw meat has 5.77 percent, and the cooked, 9.19 percent.

The composition of the total soluble ash does not vary much with the method of cooking, having for the boiled meat, 20.20 percent phosphorus, for the pot-roasted, 21.28 percent, and for the oven-roasted, 20.52 percent. The slight difference between the pot and oven-roast meat seems to be in the inorganic phosphorus, the amount being in the former case, 15.86 percent, and in the latter case, 14.85 percent. The organic phosphorus is practically the same. In the pot-roast it is 5.42 percent of the total soluble, and in the oven-roast, 5.67 percent. From this, it can be seen that the organic phosphorus in the meats cooked by these two methods, constitutes approximately one-fourth of the phosphorus content of the soluble ash, and that the inorganic phosphorus constitutes the other three-fourths.

FORMS of PHOSPHORUS EXPRESSED in PERCENTAGE
of TOTAL NITROGEN.

SOLUBLE FORMS of PHOSPHORUS EXPRESSED in PERCENTAGE
of TOTAL SOLUBLE NITROGEN.

Table 24. - Calculated on the Basis of the Raw Meat.

Table 25. - Calculated on the Basis of the Cooked Meat.

Table 24

Forms of Phosphorus Expressed in Percentage of Total Nitrogen

Soluble Forms of Phosphorus Expressed in Percentage of Total Soluble Nitrogen

Laboratory No.	Kind of Meat	Total Nitrogen	Soluble Nitrogen	Total Nitrogen: Soluble: Inorganic	Total Nitrogen: Soluble: Organic	Total Nitrogen: Soluble: Total	Total Nitrogen: Insoluble: Direct	Total Nitrogen: Insoluble: Indirect	Total Nitrogen: Total	Soluble Nitrogen: Inorganic	Soluble Nitrogen: Organic	Soluble Nitrogen: Total
		%	%	%	%	%	%	%	%	%	%	%
1788	Beef, round, raw	3.6530	.7798	3.42	1.18	4.60	1.48	1.42	6.02	16.03	5.51	21.54
1789	do	3.3650	.7480	3.03	1.31	4.34	1.52	1.90	6.24	13.64	5.88	19.52
1823	do	3.3440	.7885	2.69	2.54	5.23	2.18	1.41	6.64	11.41	10.77	22.18
1828	do	3.3620	.7377	3.03	1.43	4.46	1.78	1.78	6.24	13.82	6.50	20.32
1849	do	3.5450	.8884	4.19	2.86	7.04	2.23	1.75	8.80	16.67	11.37	28.04
1850	do	3.4060	.8998	4.49	3.05	7.54	2.67	2.58	10.12	17.00	11.55	28.55
	Average (6)	3.4458	.8070	3.48	2.05	5.53	1.98	1.81	7.34	14.76	8.60	23.36
1853	Veal shank raw	3.3510	.5687	2.63	1.04	3.67	2.09	1.61	5.28	15.48	6.15	21.63
1854	do chuck do	3.2270	.5536	2.70	1.11	3.81	2.17	2.17	5.98	15.72	6.50	22.22
1855	do ribs do	2.9340	.5904	3.20	1.13	4.33	2.32	3.71	8.04	15.92	5.59	21.51
1856	do ribs & shoulder do	3.0670	.5988	3.32	1.01	4.33	4.01	4.43	8.77	17.05	5.17	22.21
1857	do breast do	2.9530	.5367	2.54	1.25	3.79	2.44	1.90	5.69	13.97	6.90	20.87
1858	do loin do	3.0390	.6001	3.03	1.35	4.38	2.47	1.74	6.12	15.33	6.83	22.16
1859	do flank do	3.0500	.5889	3.13	.60	3.73	2.10	...	5.82	15.96	3.06	19.02
1860	do leg do	3.2840	.6790	3.59	1.19	4.78	1.77	1.95	6.73	17.38	5.74	23.12
1861	do hind shank do	3.3300	.6257	3.28	.69	3.97	2.05	1.78	5.75	17.42	3.68	21.10
	Average (9)	3.1361	.5935	3.05	1.04	4.09	2.38	2.41	6.46	16.02	5.52	21.54

Table 25 Forms of Phosphorus Expressed in Percentage of Total Nitrogen
Soluble Forms of Phosphorus Expressed in Percentage of Total Soluble Nitrogen

Laboratory No.	Kind of Meat	Cooking Experiment No.	Method of Cooking: Kind	Temperature: Beginning °C	Temperature: During °C	Time hrs min	Total Nitrogen %	Soluble Nitrogen %	Total Nitrogen: Soluble: Inorganic %	Soluble: Organic %	Soluble: Total %	Insoluble: Digest %	Insoluble: Indigest %	Total %	Soluble Nitrogen: Inorganic	Soluble Nitrogen: Organic	Soluble Nitrogen: Total
1801	Beef, round	158	Boiling	Cold	85	3 30	5.6860	.1769	- -	- -	1.32	- -	1.53	2.85	- -	- -	42.40
1807	do	161	do	do	85	6 00	5.2490	.1816	- -	- -	1.28	- -	1.45	2.73	- -	- -	36.89
	Average (2)						5.4675	.1793	- -	- -	1.30	- -	1.49	2.79	- -	- -	39.65
1808	Beef, round	162	Boiling	100	85	6 00	5.5550	.2038	- -	- -	1.22	- -	1.70	2.92	- -	- -	33.37
1802	do	159	do	100	85	3 00	5.8860	.1823	- -	- -	1.24	- -	1.60	2.84	- -	- -	40.04
	Average (2)						5.7205	.1931	- -	- -	1.23	- -	1.65	2.88	- -	- -	36.72
1824	Beef, round	164	Boiling	100	100	3 00	5.6110	.3046	1.51	.73	2.25	- -	1.55	3.80	27.91	13.46	41.37
1809	do	163	do	100	100	5 00	5.7420	.3472	- -	- -	1.41	- -	1.39	2.80	- -	- -	23.33
1803	do	160	do	100	100	2 30	5.9630	.2534	- -	- -	1.36	- -	1.44	2.80	- -	- -	31.97
	Average (3)						5.7720	.3017	- -	- -	1.67	- -	1.46	3.13	- -	- -	32.22
	Average (7)						5.6703	.2357	- -	- -	1.44	- -	1.52	2.96	- -	- -	35.62
1825	Beef, round	165	Pot roast	- -	- -	3 00	5.9690	.4783	2.04	.99	3.03	- -	1.39	4.42	25.51	12.34	37.84
1829	do	166	do	- -	- -	3 00	6.0180	.3953	1.86	.82	2.68	1.66	1.09	3.77	28.33	12.40	40.76
1830	do	167	do	- -	- -	3 00	5.3060	.3365	1.96	.34	2.30	1.55	1.94	4.24	30.91	5.35	36.26
	Average (3)						5.7643	.4034	1.95	.72	2.67	1.60	1.47	4.14	28.25	10.04	38.29
1831	Beef, rib 4th	168	Roast	250	195	1 00	2.7790	.3300	3.42	.83	4.25	1.69	1.08	5.33	28.79	6.97	35.76
1833	do 3d & 4th	169	do	250	195	1 40	3.0600	.3678	2.91	1.14	4.05	1.44	1.11	5.16	24.20	9.51	33.71
1837	do do	170	do	250	195	1 30	3.3380	.3671	2.67	1.16	3.83	2.19	1.77	5.60	24.25	10.62	34.87
1838	do do	171	do	250	195	1 35	3.4960	.3520	2.97	1.26	4.23	1.57	1.20	5.43	29.55	12.50	42.05
1840	do do	172	do	250	195	2 15	3.1960	.3086	2.53	1.19	3.72	1.75	1.50	5.23	26.25	12.31	38.56
1848	do do	176	do	250	195	2 15	3.8320	.3981	2.66	1.23	3.89	- -	1.28	5.17	25.62	11.81	37.43
1842	do do	173	do	250	195	1 50	2.9510	.3207	3.05	1.08	4.13	2.07	1.26	5.39	28.06	9.98	38.04
1844	do do	174	do	250	195	3 00	3.6310	.3271	2.67	1.16	3.83	1.84	1.49	5.32	29.65	12.84	42.49
1846	do do	175	do	250	195	2 45	4.1650	.3902	2.88	.90	3.79	1.63	1.34	5.13	30.75	9.74	40.49
	Average (9)						3.3853	.3513	2.86	1.11	3.97	1.77	1.34	5.31	27.46	10.70	38.16

In considering the various phases of this question, it was thought that perhaps the data expressed in percent of the total nitrogen would throw some light upon the nature of the organic phosphorus, and at the same time show that a definite relation existed between the other forms of phosphorus and those of the nitrogen.

In studying the data in tables Nos. 24-25, it will be seen, that, in the case of the raw beef, the percent of soluble organic phosphorus varies from 1.18 to 3.05, giving as an average for the six tests, 2.05 percent. In the case of the veal, the variations are not so great, being from 0.60 to 1.35 percent, with an average for all experiments of 1.04 percent. This shows that the relation of the organic phosphorus in the total nitrogen is 100 percent greater in the beef than in the veal, and again indicates the influence of age. The same general differences between these two meats is noticeable in comparing the soluble forms of phosphorus with the soluble nitrogen. In the beef, the percents of organic phosphorus vary from 5.51 to 11.55, averaging for all the tests, 8.60 percent, and in the veal the maximum percent is 6.90, the minimum, 3.06, with a total average of 5.52.

Taking up the cooked meats, there is a very little difference in the percent of total phosphorus in the case of that cooked by boiling, the average being for the three methods, beginning with the lowest temperature, 2.79, 2.88 and 3.13 percent,

respectively. The average for all the boiled meats is 2.96 percent, for all the pot-roast meats, 4.14 percent, and for the oven-roast, 5.31 percent, showing that a definite distinction can be made between the three general methods of cooking.

The relation of the soluble inorganic phosphorus in the total nitrogen is fairly constant for the two methods of roasting. In the pot-roast meat, the variations are from 1.86 to 2.04 percent, averaging 1.95 percent, and in the oven-roast meat it ranges from 2.66 to 3.42 percent, giving as an average for the nine experiments, 2.86 percent.

In the case of the organic phosphorus, it will be seen that its percentages of the total nitrogen would be quite close for the pot-roast and oven-roast meats, if we eliminated the determination for No. 1830, for then they would be 0.91 and 1.11, respectively. On the other hand, the percentage would be 35 percent lower in the pot-roast than in the oven-roast.

The relation of the total soluble nitrogen to the soluble forms of phosphorus in cooked meats is quite constant in the case of the roasts. For example, their percentage of total soluble phosphorus of the total nitrogen is 38.29 for the pot-roast, with a variation from 36.26 to 40.76, and for the oven-roast meat it is 38.16 percent, with a maximum and minimum percent of 42.49 and 33.71 respectively. The percentage of organic phosphorus is 10.04 in the case of the pot-roast, and 10.10 for the oven-roast, and that for the inorganic phosphorus is 28.25 and 27.46, respectively, for the pot and oven-roast meats. The percentage of the total soluble phosphorus in the soluble nitrogen is, for the average of all the boiling experiments, 35.26, with a maximum of 42.40, and a minimum

of 23.33.

In comparing the average percentages of the total phosphorus in the total nitrogen, of the raw beef round, with those of the cooked meat, it will be seen that there is a decrease for both the boiled and pot-roast meats, the raw meat being 7.34, the boiled 2.96, and the pot-roast 4.14 percent. The relation of the total soluble phosphorus in the total nitrogen of the cooked meats also decreases, being for the raw beef, 5.53 percent, the boiled, 1.44 percent, and the pot-roast, 2.67 percent.

Again, in considering the percentages of the total soluble phosphorus in the total soluble nitrogen, we find that they increase in the cooked meats, the raw being 23.36 percent, the boiled, 35.62 percent, and the pot-roast, 38.29 percent. From this, we see that the relation of the total nitrogen to both the total and soluble phosphorus shows a greater difference for the raw meat than for the cooked, and that, in the case of the total soluble nitrogen, it shows a greater difference for the cooked meats.

FORMS of PHOSPHORUS EXPRESSED in PERCENTAGE
of NITROGENOUS EXTRACTIVES.

Table 26. - Calculated on the Basis of the Raw Substance.

Table 27. - Calculated on the Basis of the Cooked Substance.

Table 26

Forms of Phosphorus

Expressed in Percentage of Nitrogenous Organic Extractives

Laboratory No.	Kind of Meat	Nitrogenous Extractives %	Nitrogenous Extractives					
			Soluble			Insoluble		
			Inorganic %	Organic %	Total %	Direct %	Indirect %	Total %
1788	Beef, round, raw	1.23	10.16	3.50	13.66	4.39	4.23	17.89
1789	do	1.13	9.03	3.89	12.92	4.53	5.66	18.58
1823	do	1.26	7.14	6.75	13.89	5.80	3.73	17.62
1828	do	1.20	8.50	4.00	12.50	5.00	5.00	17.50
1849	do	1.29	11.47	7.83	19.30	6.12	4.80	24.11
1850	do	1.34	11.42	7.76	19.18	6.79	6.57	25.75
	Average (6)	1.24	9.62	5.62	15.24	5.44	5.00	20.24
1853	Veal, shank, raw	.74	11.89	4.73	16.62	9.46	7.30	23.92
1854	do chuck do	.82	10.61	4.39	15.00	8.54	8.54	23.54
1855	do ribs do	.98	9.59	3.37	12.96	6.94	11.12	24.08
1856	do ribs & shoulder do	.93	10.97	3.33	14.30	13.23	14.62	28.92
1857	do breast do	.78	9.61	4.74	14.36	9.23	7.18	21.54
1858	do loin do	.98	9.39	4.18	13.57	7.65	5.41	18.98
1859	do flank do	.92	10.22	1.96	12.17	6.85	...	19.02
1860	do leg do	1.21	9.75	3.22	12.97	4.79	5.29	18.26
1861	do hind shank do	.98	11.12	2.35	13.47	6.94	6.02	19.49
	Average (9)	.93	10.35	3.59	13.94	8.18	8.19	21.97

Table 27

Forms of Phosphorus
Expressed in Percentage of Nitrogenous Organic Extractives

Laboratory No.	Kind of Meat	Cooking Experiment No.	Method of Cooking: Kind	Temperature: Beginning °C	Temperature: During °C	Time hrs. min	Nitrogenous Extractives %	Nitrogenous Extractives, Soluble: Inorganic %	Soluble: Organic %	Soluble: Total %	Insoluble: Direct %	Insoluble: Indirect %	Total %
1801	Beef, round	158	Boiling	Cold	85	3 30	.48	..	..	15.63	..	18.12	33.75
1807	do	161	do	do	85	6 00	.44	..	..	15.23	..	17.27	32.50
	Average (2)						.46	..	..	15.43	..	17.70	33.13
1808	Beef, round	162	Boiling	100	85	6 00	.47	..	..	14.47	..	20.00	34.47
1802	do	159	do	100	85	3 00	.48	..	..	15.21	..	19.58	34.79
	Average (2)						.48	..	..	14.84	..	19.80	34.64
1824	Beef, round	164	Boiling	100	100	3 00	.83	10.24	4.94	15.18	..	10.48	25.66
1809	do	163	do	100	100	5 00	.57	..	..	14.21	..	14.04	28.25
1803	do	160	do	100	100	2 30	.53	..	..	15.28	..	16.23	31.51
	Average (3)						.64	..	..	14.89	..	13.58	28.47
	Average (7)						.54	..	..	15.03	..	16.53	31.56
1825	Beef, round	165	Pot-roast	..	..	3 00	1.31	9.31	4.50	13.81	..	6.34	20.15
1829	do	166	do	..	..	3 00	1.01	11.09	4.85	15.94	9.90	6.53	22.48
1830	do	167	do	..	..	3 00	.85	12.23	2.12	14.35	9.65	12.12	26.47
	Average (3)						1.06	10.88	3.82	14.70	9.78	8.33	23.03
1831	Beef, rib, 4th	168	Roast	250	195	1 00	.77	12.39	2.99	15.33	6.10	3.89	19.22
1833	do 3d+4th	169	do	250	195	1 40	.86	10.35	4.07	14.42	5.12	3.95	18.37
1837	do do	170	do	250	195	1 30	.91	9.78	4.29	14.07	8.02	6.48	20.55
1838	do do	171	do	250	195	1 35	.91	11.43	4.83	16.26	6.04	4.62	20.88
1840	do do	172	do	250	195	2 15	.80	10.13	4.75	14.88	7.00	6.00	20.88
1848	do do	176	do	250	195	2 15	1.06	9.62	4.43	14.06	..	4.62	18.68
1842	do do	173	do	250	195	1 50	.85	10.59	3.76	14.35	7.17	4.35	18.71
1844	do do	174	do	250	195	3 00	.89	10.90	4.72	15.62	7.53	6.01	21.69
1846	do do	175	do	250	195	2 45	1.09	11.01	3.49	14.50	6.24	5.14	19.64
	Average (9)						.90	10.68	4.15	14.83	6.65	5.02	19.85

In considering the relation of the nitrogenous extractives to the forms of phosphorus, it was thought that there might be some factor which would aid in identifying the organic form of phosphorus. We have, as yet, been unable to accomplish this point. The most common extractives contain a much higher amount of phosphorus than our data represents.

Taking up a study of the percent of the forms of phosphorus to the nitrogenous extractives in raw meats, it will be seen that the average for the six tests upon the beef round is 20.24 percent for the total, 15.24 percent for the total soluble, 5.62 percent for the organic, and 9.62 percent for the inorganic phosphorus, while the average of the veal experiments represents for the total, 21.29 percent, for the total soluble, 13.94 percent, for the organic, 3.59 percent, and for the inorganic 10.35 percent. This shows, first that the percent of organic phosphorus is very low compared with that of the ordinary organic extractives containing phosphorus, and second that the differences between the percents of the beef round and the veal are greater for the total soluble and the organic phosphorus, being 15.24, 13.94 percent, and 5.62, 3.59 percent, respectively.

In the cooked meats, the percentages of the total phosphorus vary directly with the method used, being 31.56 for the boiled, 23.03 for the pot-roast, and 19.85 for the oven-roast. The insoluble phosphorus varies in the same manner, and as a result there is

very little difference in the percents of the total soluble phosphorus of the two meats. The boiled meat has a percentage of 15.03, the pot-roast, of 14.70, and the oven roast, of 14.83. The organic and inorganic phosphorus are distributed about equally in each case, being for the pot-roast, 3.87 and 4.15 percent, and for the oven-roast, 10.88 and 10.68 percent, respectively.

FORMS of PHOSPHORUS EXPRESSED in PERCENTAGE of
NON-NITROGENOUS ORGANIC EXTRACTIVES.

Table 28. - Calculated on the Basis of Fresh Meat.

Table 29. - Calculated on the Basis of the Cooked Meat.

Table 28

Forms of Phosphorus

Expressed in Percentage of Non-nitrogenous Organic Extractives

Laboratory No.	Kind of Meat	Non-nitrogenous Extractives %	Non-nitrogenous Extractives: Soluble: Inorganic %	Soluble: Organic %	Soluble: Total %	Insoluble: Direct %	Insoluble: Indirect %	Total %
1788	Beef, round, raw	1.55	8.06	2.78	10.84	3.48	3.35	14.19
1789	do	1.55	6.58	2.84	9.42	3.29	4.13	13.55
1823	do	1.54	5.84	5.52	11.36	4.74	3.05	14.41
1828	do	1.56	6.54	3.07	9.61	3.85	3.85	13.46
1849	do	1.86	7.96	5.43	13.39	4.25	3.33	16.72
1850	do	2.00	7.65	5.20	12.85	4.55	4.40	17.25
	Average (6)	1.68	7.10	4.14	11.24	4.03	3.69	14.93
1853	Veal, shank, raw	1.19	7.39	2.94	10.33	5.88	4.54	14.87
1854	do chuck do	1.31	6.64	2.75	9.39	5.34	5.34	14.73
1855	do ribs do	1.49	6.31	2.21	8.52	4.56	7.32	15.84
1856	do ribs & shoulder do	1.44	7.08	2.16	9.24	8.54	9.44	18.68
1857	do breast do	1.42	5.28	2.61	7.89	5.07	3.94	11.83
1858	do loin do	1.46	6.30	2.81	9.11	5.14	3.63	12.73
1859	do flank do	1.16	8.10	1.56	9.66	5.43	...	15.09
1860	do leg do	1.87	6.31	2.09	8.40	3.10	3.42	11.82
1861	do hind shank do	1.42	7.68	1.62	9.30	4.79	4.15	13.45
	Average (9)	1.42	6.79	2.30	9.09	5.32	5.22	14.34

Table 29

Forms of Phosphorus
Expressed in Percentage of Non-nitrogenous Organic Extractives

Laboratory No.	Kind of Meat	Cooking Experiment No.	Method of Cooking				Non-nitrogenous Extractives %	Non-nitrogenous Extractives					
			Kind	Temperature		Time		Soluble			Insoluble		
				Beginning °C	During °C	hrs min		Inorganic %	Organic %	Total %	Inorganic %	Organic %	Total %
1801	Beef, round	158	Boiling	Cold	85	3 30	.52	- -	- -	14.42	- -	16.73	31.15
1807	do	161	do	do	85	6 00	.53	- -	- -	12.64	- -	14.34	26.98
	Average (2)						.53	- -	- -	13.53	- -	15.54	29.07
1808	Beef, round	162	Boiling	100	85	6 00	.54	- -	- -	12.59	- -	17.41	30.00
1802	do	159	do	100	85	3 00	.64	- -	- -	11.41	- -	14.69	26.10
	Average (2)						.59	- -	- -	12.00	- -	16.05	28.05
1824	Beef, round	164	Boiling	100	100	3 00	1.06	8.02	3.87	11.89	- -	8.20	20.09
1809	do	163	do	100	100	5 00	.64	- -	- -	12.66	- -	12.50	25.16
1803	do	160	do	100	100	2 30	.59	- -	- -	11.74	- -	12.46	24.20
	Average (3)						.80	- -	- -	12.10	- -	11.05	23.15
	Average (7)						.66	- -	- -	12.48	- -	13.76	26.24
1825	Beef, round	165	Pot-roast	- -	- -	3 00	1.53	7.97	3.86	11.83	- -	5.43	17.26
1829	do	166	do	- -	- -	3 00	1.09	10.28	4.50	14.77	9.17	6.06	20.83
1830	do	167	do	- -	- -	3 00	.95	10.95	1.89	12.84	8.63	10.84	23.67
	Average (3)						1.19	9.73	3.42	13.15	8.90	7.44	20.59
1831	Beef, rib, 4th	168	Roast	250	195	1 00	.82	11.59	2.80	14.39	5.73	3.65	18.05
1833	do 3d & 4th	169	do	250	195	1 40	1.15	7.74	3.04	10.78	3.83	2.96	13.74
1837	do do	170	do	250	195	1 30	1.02	8.73	3.82	12.55	7.16	5.78	18.33
1838	do do	171	do	250	195	1 35	1.04	10.00	4.23	14.23	5.29	4.04	18.27
1840	do do	172	do	250	195	2 15	.97	8.35	3.92	12.27	5.77	4.95	17.22
1848	do do	176	do	250	195	2 15	1.19	8.57	3.95	12.52	- -	4.12	16.64
1842	do do	173	do	250	195	1 50	.97	9.28	3.30	12.58	6.29	3.81	16.39
1844	do do	174	do	250	195	3 00	1.01	9.60	4.16	13.76	6.63	5.34	19.11
1846	do do	175	do	250	195	2 45	1.51	7.95	2.51	10.46	4.50	3.71	14.17
	Average (9)						1.08	9.09	3.53	12.62	5.65	4.26	16.88

This data was originally tabulated in this form in order to ascertain whether there was any constant factor between the non-nitrogenous organic extractives and the soluble organic phosphorus. In the raw meats, the data show nothing definite, and in the cooked meats the percents, while fairly constant, being 3.42 percent for the pot-roast, and 3.53 percent for the oven-roast, are too low when compared with any of the known phosphorus containing extractives.

The most marked difference between the raw beef and veal, as regards the relation of the non-nitrogenous extractive matter to the various forms of phosphorus, lies in the total soluble and the organic. In the first case, the average for the six analyses of beef is 11.24 percent, and for the nine of veal, 9.09 percent, and in the case of the organic phosphorus the average for the beef and veal is 4.14 and 2.30 percent, respectively. It will be seen from this that the variation in the percent of the total soluble phosphorus content is due to the difference in the soluble organic phosphorus.

The cooked meats show some definite variations. In the case of the boiled meat, the percent of the total phosphorus decreases as the temperature of cooking rises. The average percent for the tests where the meat was first placed in cold water and then heated to 85° C., is 29.07; for the ones where the temperature was 100° C. at the start, then 85° C., is 28.05, and for those where the temperature was 100° C. throughout, it is 23.15. The average

for all the boiled meats is 26.24 percent. The percents for the soluble phosphorus do not vary so much, being 13.53 for the meat placed in cold water and heated to 85^{0}C., 12.00 and 12.10 for that cooked at the other two temperatures, with an average for all of 12.48 percent.

In comparing the average of the boiled meats with those for the pot and oven-roast meats, we find that the percent of the total phosphorus decreases in the order of the methods named, the boiled meat being 26.24 percent, the pot-roast 20.59 percent, and the oven-roast 16.88 percent. The percents of the total soluble phosphorus are, for the boiled meat, 12.48, for the pot-roast, 13.15, and for the oven-roast, 12.62. The relation of the organic and inorganic phosphorus is quite constant in the case of the pot and oven-roasted meats, being respectively, 9.73 percent and 3.42 percent in the first case, 9.09 percent and 3.53 percent in the second case.

A PRELIMINARY STUDY of the SOLUBLE ORGANIC PHOSPHORUS.

An attempt was made to locate the nature of the soluble organic phosphorus in meat. It has previously been proven that the albumen is practically free from phosphorus, by evaporating a large portion of the water extract and filtering off the resulting coagulum, and then determining the amount of phosphorus, after oxidizing it by the Newman method. The next step was to investigate the other proteid bodies. Several portions of the extract were treated in the usual.manner for estimating the so-called albumoses, by saturation with zinc sulphate. The precipitates from this

treatment were combined, oxidized in the usual manner and tested for phosphates. It was thought best to remove some of the zinc sulphate and then test the filtrate. No trace of phosphorus was found, showing that the albumoses were not in combination with this element. Knowing that the albumen and albumoses did not contain any phosphorus, the precipitate, from the treatment of tannin and salt, which contains all the proteids - albumen, albumoses and any peptones - was analyzed. After oxidation, neutralization and etc., it was tested and found to be free from any phosphorus. As a result, the conclusion is that the organic phosphorus was not in combination with the proteid molecule.

A test was next made to determine whether a part of the organic phosphorus might not be there as lecithin, due to the small amount of blood in the extract. Accordingly, five liters of the water extract, as usually made, was carefully evaporated upon the water bath to about 300 c.c. The coaguable albumen was then filtered off and thoroughly washed with hot water. The washings and filtrate were then evaporated to about 15 c.c., when the thick liquid was transferred to a small weighed dish containing some ignited sand and a glass rod. The sand had been previously washed with hot alcohol and ether. The above liquid was then evaporated to dryness upon the water bath and finally dried in a water oven until about constant in weight. It weighed 3.0395 grams.

The dried residue was then quickly ground up, put in a Soxhlet tube, and extracted with ether for about five hours. The tube was then connected with a flask containing 95 percent alcohol, and again extracted for five hours. This alternate treatment was repeated twice. The solvents were then distilled off, and the

residues heated until constant in weight. The alcoholic extract weighed 1.1542 grams, and the ether extract, 0.0207 grams. Both of these residues contained crystals and a gummy mass. The crystals in the alcoholic extract were needles arranged in knots and bundles, while those in the ether extract were also needles arranged in stars.

The application of cold water to each did not seem to effect the crystals, and heating did not aid in their solution. However, considerable of the noncrystallizable matter dissolved. A separation of the two lots of crystals from the gummy mass was made by repeated treatments with hot water and then filtration. The phosphorus was estimated in each of these four portions by oxidizing them and then proceeding in the usual manner. In but one case did we obtain any of the yellow precipitate. This was in the portion of the alcoholic extract soluble in water. The amount found was exceedingly small. As a result, it was decided, as far as this test went, that there was no lecithin in the water extract of meat.

A PRELIMINARY STUDY of the INSOLUBLE RESIDUES from the COLD WATER EXTRACTION of MEAT.

From our experimental data in determining the phosphorus content of meats, it is evident that some of the phosphorus compounds which exist in flesh are not dissolved by our cold water extraction method. Nucleo-proteids, lecithin, calcium and magnesium phosphate are among these. Hammarsten[53] states that the native nucleo-proteids are insoluble in water and dilute acids but soluble

in salt solutions and alkali. Pekelharing[54] has also shown in his work upon the nucleo-proteids in muscle, that they are insoluble in acid solution and soluble in alkali. Lecithin is insoluble in water but a large excess forms, according to Hammarsten, an emulsion which is a"filterable colloidal solution". In our preliminary work upon the soluble organic phosphorus, we found that lecithin was practically absent from the water extract. Lecithin combines with such acids as hydrochloric, yet it is difficultly soluble in the media. Calcium phosphate is very slightly soluble in cold water. It is soluble, according to Crum[55], in very dilute hydrochloric acid, more easily, however, in lactic, acetic and malic acids. We know that the water extract of meat is very slightly acid, and hence it may be expected that some of the calcium salt is dissolved by this treatment.

Two experiments were undertaken, with the idea of attempting a more or less complete separation of these forms of phosphorus which are insoluble in cold water, and also to investigate the phosphorus content of some of the soluble coaguable proteids. The insoluble residues from the extraction of a sample of meat were transferred to a large flask, and treated with 0.2 percent solution of hydrochloric acid for three days. It was supposed that in this way the calcium and magnesium phosphates would be put into solution, and that the nucleo-proteids and lecithin would remain undissolved. The hydrochloric acid extract was then filtered and made up to a definite volume. It was analyzed for phosphorus, the total soluble, the inorganic and organic forms being estimated as usual. A portion of the solution was also evaporated to a small volume upon the water bath, neutralized, and again heated. The resulting coagulum

was then filtered off and washed thoroughly with hot water, after which its phosphorus content was determined. The results are given in table No. 30.

In referring to this data, it will be seen that 58.93 percent of the phosphorus which is insoluble in water dissolves in a 0.2 percent solution of hydrochloric acid. Of this soluble phosphorus, 21.18 percent is inorganic due to the calcium salt, and 78.82 percent is organic, apparently due, chiefly to some coaguable proteid. The insoluble residues contain 41.07 percent of the phosphorus left from the water extraction. This represents that due to lecithin and nucleo-proteids.

The second experiment was conducted upon the same sample of meat as the first. A cold water extract was made as usual, and the insoluble residues were treated successively with reagents. First, they were extracted with a 10 percent ammonium sulphate solution, using the same method of procedure as in the case of the water. The extraction was continued until a portion of the clear filtrate gave no test for proteid matter. The solution, which measured about four liters, was then made up to a definite volume. The total phosphorus was estimated in one portion,and in another the phosphorus in the coagulum which separated after evaporation and neutralization. It was hoped that by this procedure the nucleo-proteid might be isolated.

The next step was to remove all the ammonium sulphate from the residues, in order that an extraction might then be made with hydrochloric acid and thereby separate the calcium phosphate. The residues were washed with cold water. It was found that the filtrate contained considerable proteid matter, and as a result, a

complete extraction was made, removing both the soluble proteid and the ammonium sulphate. This solution was then analyzed for phosphorus with the idea that, if any existed there, it would probably be due to the calcium salts which are quite easily soluble in weak salt solutions.

The insoluble portions, left from the last water extract, were now treated with a 0.2 percent hydrochloric acid solution until a portion of the clear filtrate proved the absence of proteid matter. The solution was then analyzed for total, inorganic and organic phosphorus. A portion was also evaporated to a small volume, neutralized and freed from the resulting coagulum. The phosphorus was estimated in this.

The residues from the 0.2 percent hydrochloric acid extract were now treated with water, in order to remove all the acid so as to treat the insoluble portions with dilute alkali. It appeared, however, that after the water extraction had been completed, the residues had been almost entirely dissolved, and that it was not necessary to use the alkali. The water extract was analyzed in the usual manner for phosphorus. The results of these several extractions are given in the following table.

SUMMARY of the ANALYSES of the RESIDUES

INSOLUBLE in COLD WATER.

Table 30. - Calculated to the Fresh Basis.

Table 30

Summary of Preliminary Analysis of the Residues Insoluble in Cold Water

Calculated to the Fresh Basis

Description of Sample	Extracting Agent	Soluble Phosphorus: Coagulum	Soluble Phosphorus: Inorganic	Soluble Phosphorus: Organic	Soluble Phosphorus: Total	Insoluble	Total
A Beef, round, raw	Water	--	.095	.074	.169	.056	.224
First Experiment							
B Residues insoluble in water (A)	.2% HCl	.014	.007	.026	.033	.023	.056
Second Experiment							
C Residues insoluble in water (A)	10% $(NH_4)_2SO_4$	.002	--	--	.007	.049	.056
D Residues insoluble in 10% $(NH_4)_2SO_4$ (C)	Water	--	--	--	.014	.035	.049
E Residues insoluble in water (D)	.2% HCl	.002	.001	.003	.004	.031	.035
F Residues insoluble in .2% HCl (E)	Water	--	.001	.017	.018	.013	.031

It will be seen, in referring to the data of the second experiment (Table 30), that the treatment with 10 percent ammonium sulphate removed 12.5 percent of the phosphorus in the residues which were insoluble in water. This amount is probably due to the nucleo-proteids. The phosphorus in the coagulum aids in establishing this fact, although, upon coagulating nucleo-proteids nuclein split off and carry away most of the phosphorus. The determination of the total soluble phosphorus in the water extract, following that of the ammonium sulphate, represent 25 percent of that in the original residues. This is chiefly calcium phosphate with perhaps a small amount of nucleo-proteid. In considering the 0.2 percent hydrochloric acid extract, we see that it contains 7.1 percent of phosphorus, and of this, 1.8 percent is inorganic and 6.2 percent organic. The small amount of the inorganic form is due to the calcium salt, and that of the organic is probably due to both nucleo-proteids and nucleins, since they are very slightly soluble in dilute acids. Concerning the water extract of the residue from the acid treatment, nothing definite can be said other than that the phosphorus content, which is apparently organic, constitutes 32.10 percent of the total phosphorus in the original residue from the water extraction.

We have then separated by these successive treatments of the insoluble residues from the cold water extraction: with ammonium sulphate 12.5 percent of phosphorus due to nucleo-proteids, with water 25.0 percent due to phosphates of calcium, with hydro-

chloric acid 1.8 percent of phosphorus from calcium salts and 6.2 percent due to nucleins, and with water 32.1 percent due to some organic compound. This leaves 23.4 percent of phosphorus in the original residues which is probably due to lecithin. Or, calculated upon the basis of the fresh meat, these extracts contain, for the ammonium sulphate, water, hydrochloric acid, and water 0.007 percent, 0.014 percent, 0.004 percent, and 0.018 percent, respectively, of phosphorus, leaving 0.013 percent of the phosphorus for lecithin.

CONCLUSIONS.

From the present study of the phosphorus content of raw and cooked meats, a few conclusions, based upon our experimental data, follow.

1. That the method of separating the water soluble inorganic phosphorus is quantitative and apparently complete.

2. That the water-soluble organic phosphorus is not in combination with the coagulable proteid, with albumoses, peptones, lecithin or nucleo-proteid.

3. That there is a difference in the phosphorus content of beef and veal, depending upon either the age or feed.

(a) 75 percent of the total phosphorus in beef, and 64 percent in veal is soluble in cold water.

(b) Of the total phosphorus, one-fourth is organic in the beef, and one-sixth in the veal.

(c) The organic phosphorus in beef round constitutes one-third of the total soluble phosphorus, and in the veal one-fourth.

(d) The ratio of the organic to the inorganic phosphorus is, in the beef, 3 : 5, and in the veal, 1 : 3.

(e) 23.4 percent of the ash in beef, and 20.2 percent in veal is phosphorus.

(f) 17.8 percent of the ash in beef, and 12.8 percent in veal is soluble phosphorus.

(g) 50 percent of the total phosphorus in the beef and the veal is inorganic.

4. That the fore quarter of the veal contains more total, organic and insoluble phosphorus than the hind quarter, being respectively 10, 13, and 32 percent greater.

5. That the percent of fat in the different cuts of veal has little influence upon the total phosphorus content.

6. That the cuts of veal which are nearest the bony structure contain more insoluble phosphorus than the others, probably due to the calcium phosphate in the bone.

7. That the percents of the forms of phosphorus show a difference in the composition of meats cooked by the three methods of boiling, varying directly with the rise in temperature. This is shown best when calculated in percent of the total nitrogen and non-nitrogenous extractives.

8. That the percents of the forms of phosphorus show a definite variation in the composition of meats cooked by boiling, pot-roasting, and oven-roasting, when the total phosphorus and the soluble phosphorus are calculated to the water and fat-free basis, when the total soluble phosphorus is calculated in percent of the

total phosphorus, and when the total phosphorus is in percent of the total ash.

9. That boiled meat loses a little over one-half of its total phosphorus, and about three-fourths of its soluble phosphorus. Pot-roast meat loses two-fifths of its total, and one-half of its soluble phosphorus.

10. That of the soluble phosphorus in cooked meats, two-thirds of it is inorganic in the case of boiled meat, and one-fourth in the case of the pot and oven-roast meats.

11. That the percent of phosphorus in the ash of cooked meats is about the same in all cases.

12. That the insoluble phosphorus is composed in part of organic and inorganic phosphorus, the organic consisting of nucleoproteid, nucleins and probably lecithin, and the inorganic chiefly of calcium phosphate.

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BIBLIGRAPHY.

1. Grindley, H. S. with McCormack, H. and Porter, H. C.
U. S.-Office of Experiment Stations Bulletin 102, 1901.
Grindley, H. S. and Mojonnier, Timothy.
U. S.-Office of Experiment Stations Bulletin 141, 1904.

2. Grindley, H. S. and Mojonnier, Timothy.
U. S.-Office of Experiment Stations Bulletin (in press)

3. Grindley, H. S. and Emmett, A. D.
U. S.-Office of Experiment Stations Bulletin (in press)

4. Grindley, H. S.
Journal of American Chemical Society 26, 1086-1109, 1904.

5. Sprague, Elizabeth C. and Grindley, H. S.
University of Illinois Studies-1905 (in press)

6. Grindley, H. S. and Emmett A. D.
Journal of American Chemical Society (in press) 27, 1905.

7. Liebig, Justus Von
Animal Chemistry. Philadelphia, 1852.

8. Iwanoff, L.
Berichte der deutschen botanischen Gesellschaft, 20, 366-372, 1902.

9. Zaleski, W.
Berichte der deutschen botanischen Gesellschaft, 20, 426-433, 1902.

10. Hart, E. B. and Andrews, W. H.
American Chemical Journal 30, 470-485, 1903.
Patten, A. J. and Hart, E. B.
American Chemical Journal 31, 564-572, 1904.

11. Schulze, E. and Castoro, N.
Zeitschrift fur physiologischen Chemie 41, 477-484, 1903.

12. Berzelius, J. J.
Lehrbuch der Chemie (German translation) Berlin 9, 574, 1840

13. Chevreul, M. E.
Nouvelles Annales de Mus. d'hist. naturelle, 1, 291, 1832.

14. Schlossberger,
Annalen der Chemie 44, 343-344, 1842.

15. Enderlin, C.
Annalen der Chemie, 49, 317-339, 1844; 50, 64-67, 1844; 67, 334-349, 1848.

16. Stolzel, C.
Annalen der Chemie, 77, 256-261, 1851.

17. Staffel, E.
Annalen der Chemie, 76, 384-385, 1850.

18. Weber, R.
Annalen der Chemie, 76, 386-388, 1850.

19. Lehmann, Julius
Annalen der Chemie, 108, 357-378, 1858.

20. Echevarria,
Annalen der Chemie, 81, 373, 1852.

20a Grohe, Fr.
Annalen der Chemie 85, 233-245, 1853.

20b Valenciennes, A. and Fremy, E.
Comptes Rendus, 41, 738, 1855.

21. Liebig, Justus von
Annalen der Chemie, 62, 256-369, 1847.

22. Bibra, E. von
Archiv fur physiologische Heilkunde, 4, 536-577, 1845.

23. Keller, Franz
Annalen der Chemie 70, 91-101, 1849.

24. Bunge, G.
Zeitschrift fur Biologie, 9, 106, 1873.

25. Pott,
Landwirthschaftliche Versuchsstation, 16, 193-199, 1873.

26. Mené, Ch.
Comptes Rendus, 79, 396-397, 529, 1874.

28. Champion, P. and Pellet, H.
Comptes Rendus, 83, 488, 1876.

29. Jolly, L.
Comptes Rendus, 89, 958-959, 1879.

30. König, J.
Chemie der Menschlichen Nahrimgs-und Genussmittel 2, 125,1893

31. Weyl, Th. and Zeitler, H.
Zeitschrift für physiologische Chemie, 6, 557-565, 1882.

32. Lawes, Sir John B. and Gilbert, Jos, H.
Philosophical Transactions of the Royal Society, London, 174, 865-890, 1883.

33. Kossel, A.
Zeitschrift für physiologische Chemie 7, 7-22, 1883.

34. Bunge, G.
Zeitschrift für physiologische Chemie 9, 60-62, 1885.

35. Atwater, W. O.
American Chemical Journal, 10, 1-20, 1888.

36. Kolpakcha,
Phiziologicheskii Sbornik, Charkoff, 1:56, 1888.
(U. S.-Experiment Stations Office Bulletin 45, 308-309, 320-324, 1897.)

37. Griffiths, A. B.
Comptes Rendus 115, 562-563, 1892.

38. Whitfield, A.
Journal of Physiology 16, 487, 1893.

39. Katz, Julius
Archiv für die gesamte Physiologic, 63, 1-85, 1896.

41. Gautier, A.
Revue Hygienique, 19, 289-303, 394-415, 1897.
(Experiment Station Record, 10, 571.)

42. Williams, Miss K. I.
Journal of the Chemical Society, 71, 649-653, 1897.

43. Wiley, W. H.
U. S.-Chemistry Division, Bulletin 53, 1898.

44. Siegfried, M.
Zeitschrift fur physiologische Chemie 28, 524-529, 1899.

45. Macleod, J. J. R.
Zeitschrift fur physiologische Chemie 28, 535-558, 1899.

46. Kruger, T. R.
Zeitschrift fur physiologische Chemie 28, 530-534, 1899.

47. Percival, A. L.
Comptes Rendus 135, 1005-1007, 1902.

48. Bonanni, A.
Accad. med. di Roma v-29, 1902.
(Jahresbericht uber die Fortschritte der Thier-Chemie, 32, 537-538, 1903.)

49. Panella, A.
Arch d. Farmacol. e Terapeut. 10:322, 1902.
(Jahresbericht uber die Fortschritte der Thier-Chemie 32:525, 1903.)

50. Baimakoff,
Russki Wratsch no. 27, 1903. (Biochemisches Centralblatt 1, 745, 1903.)

51. Griffiths, A. B.
Chemical News, 91. 146-147, 1905.

52. Grete, E. A.
Konig's die untersuchung landwirtschaftlich und gewerblich-wichtiger Stoffe, Ed, 2, p. 147.

53. Hammarsten, O. and Mandel J. A.
Physiological Chemistry, Ed. 4,p. 56.

54. Pekelharing, C. A.
Zeitschrift fur physiologische Chemie 22, 244-247, 1896.

55. Crum, A.
Annalen der Chemie und Pharmacie, 63, 394, 1846.

Approved by
H. S. Grindley,
Professor of General Chemistry.

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